The Institution of Gas Engineers

JOURNAL

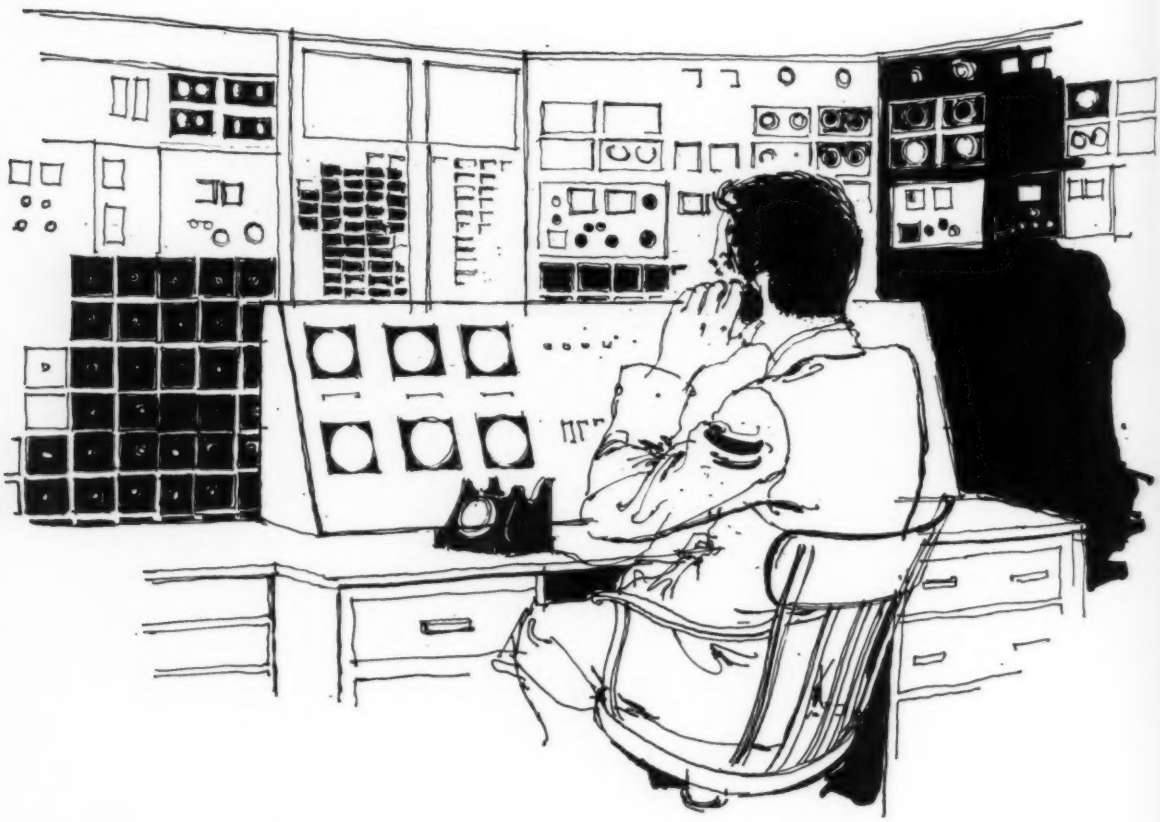
JULY 1961
VOLUME 1 NUMBER 7

Where there's gas there's Parkinson Cowan

They go together...and it's no mere passing fancy either: 150 years' experience coupled with a forward-looking policy has resulted in many new innovations in the gas industry.

Parkinson Cowan Measurement, 7/17 Fitzalan Street, London S.E.11

Remote control of holder stocks, pressure and flow by the use of the most modern telemetering and electronic techniques is one of the activities of this division. The latest addition to this range of equipment is the Parkinson Cowan Telytalk, which automatically gives information in pre-recorded speech to a distant controller over any G.P.O. telephone. Another product of this division is the Monitrol flame failure device fitted to tens of thousands of gas appliances all over the world.



Within the diversified Parkinson Cowan Group three more divisions also serve the gas industry—

Parkinson Cowan Gas Meters
Domestic meters in aluminium, steel and tin-plate; industrial and high pressure meters.

Parkinson Cowan Appliances
Domestic gas cookers, heaters and other domestic appliances.

Parkinson Cowan Industrial Products
Gas ovens and plant for paint stoving, drying or curing; Parkinson-Schwank gas radiant space heaters; rotary industrial gas meters; laboratory test meters.

HEAD OFFICE: Parkinson Cowan Limited,
Terminal House, Grosvenor Gardens, London SW1
Telephone: SLOane 0111

EXPORT: Parkinson Cowan International Limited,
Terminal House, Grosvenor Gardens, London SW1
Telephone: SLOane 0111
Cables: Disc London

PC

PARKINSON COWAN

PCM/12

The Institution of Gas Engineers

Founded 1863 Royal Charter 1929

Patron : Her Majesty The Queen

President

T. C. Battersby, M.B.E., M.I.Mech.E., M.Inst.F.

Vice-Presidents

A. E. Haffner, Ph.D., B.Sc., M.I.Chem.E., A.R.C.S., D.I.C. W. Hodkinson, O.B.E., M.I.Chem.E.

Honorary Secretary

G. E. Currier, O.B.E., M.I.Mech.E.

Secretary

A. G. Higgins, M.Sc., F.R.I.C.

Assistant Secretary

J. R. Davidson, B.Sc.

Finance Officer — A. W. King, A.A.C.C.A.

Editor — Ben. Morgan, M.A.A.

Advertisement Manager — H. P. Howell

Librarian — D. P. Johnson, B.A., A.L.A.

Vol. 1, No. 7 **JOURNAL** July, 1961

CONTENTS

	Page
Recent Industrial Gas Developments in the South West, by K. G. Eccleshare, M.Inst.F., A.M.I.Gas E., and C. H. Hirst, A.M.I.Gas E.	463
Some Considerations of Gas Making in Terms of the National Fuel Situation for the Next 25 Years, by M. W. Thring, M.A., F.Inst.P., F.Inst.F., M.I.Chem.E. (Professor of Fuel Technology and Chemical Engineering), and C. Hulse, B.Sc.(Birm), Ph.D. (Senior Lecturer, Department of Fuel Technology and Chemical Engineering, University of Sheffield	493
51st Report of the Joint Refractories Research Committee: 1959-60 (concluded)	502
New Ordinary Members of Council	510
Personal Notes	511
News from the Gas Industry Overseas:	
Deutscher Verein von Gas 'und Wasserfachmännern	512
Association Royale des Gaziers Belge	512
Abstracts of Overseas Papers	512
Forthcoming Meeting	513
In This Issue	514
Library Accessions	514
District Sections and Affiliated Associations:	
(*a*) Notes of Meetings	515
(*b*) Abstracts and Discussions of Papers	517
General Notices	521
Officers of District Sections and Affiliated Associations	522

The Institution of Gas Engineers as a body is not necessarily responsible for the statements made, nor for the opinions expressed, in the following pages.

Published by The Institution of Gas Engineers, 17, Grosvenor Crescent, London, S.W.1

Subscription Rates: 7s. 6d. per copy, post free; £4 10s. per annum, post free.

Telephone: BELgravia 8266. Telegrams: Gasophaner, Knights-London.

MAKING THE MOST OF COAL

AD INFINITUM

Simon-Carves do a lot with coal one way and another. Their specialities include skips and mine cars to bring coal to the surface, washeries to clean it, coke oven plants to carbonize it and boiler plants to burn it.

The coke oven by-products are refined in other Simon-Carves plants and pure benzene, toluene and xylene are produced, tar is distilled, naphthalene purified, tar-acids separated and anthracene oils extracted. The hydrogen from coke oven gas is used for production of ammonia in Simon-Carves fertiliser plants.

Coke is used in steelmaking and in sintering, a fact which links with many more Simon-Carves activities — in the ore preparation field, in civil engineering, in building blast furnace and steel plant dust precipitators, sulphur recovery plants and sulphuric acid plants, and so on and so on — ad infinitum (or so it seems).

Where there's industry there's coal and whichever way you look at it, Simon-Carves make the most of coal — and have been doing for seventy-odd years.

Simon-Carves Ltd

CHEADLE HEATH / STOCKPORT / ENGLAND SE MEMBER COMPANY SIMON ENGINEERING LTD

and at CALCUTTA · JOHANNESBURG · SYDNEY · TORONTO

SC 260/PS

RECENT INDUSTRIAL GAS DEVELOPMENTS IN THE SOUTH WEST

By K. G. Eccleshare, M.Inst.F., A.M.I.Gas E.

and

C. H. Hirst, A.M.I.Gas E.

Communication No. 596.

The Silver Medal (1960) of The Institution of Gas Engineers was awarded for this paper, which was read at a meeting of the South Western Section of the Institution, held in Bristol on 8th December, 1960. The discussion of this paper is reported on p. 143 of the Journal (Vol. 1, No. 2, February, 1961).

Table of Contents

		PAGE
I	Introduction	463
II	Organization	464
III	Recent Developments	465
IV	Conclusion	491
	Acknowledgments	492

I INTRODUCTION

Those of us engaged in the industrial field of the South Western Gas Board's activities recognize the challenge ahead. It is two-fold. The existing loads must be maintained to the utmost of our ability, and we must efficiently intensify our efforts, wherever thermal requirements are likely and whenever practicable, to make industry buy more gas. Two prime reasons, though others perhaps less obvious exist, clearly emphasize the importance of these aims. First, industry in all its various branches is generally active, and further increases in productivity seem evident. We have a substantial claim for a share in what goes on. Secondly, a growing and fierce competition from alternative fuels has caused a setback in the gas industry's domestic sales. The contraction here may only be transitional, but we dare not rely on the past success and dominance of our sales in the home.

Our link with industry must be a complete fuel service covering the design and installation, maintenance, survey and testing of gas-fired plant and equipment. To the various sections of any industrial concern (i.e., planning departments, production, foundry manager and maintenance staffs), the gas industry represents a reliable source of heat capable of the highest degree of control over an extremely wide range of temperatures.

The initiation of new loads has various beginnings, and by far the most successful approach is that of personal contact. Industrial press publicity has increased, but its effect is of unknown value. Planning and production engineers turn to their bulky catalogue libraries when searching for plant or equipment. They want detail and similarities; their projects often emerge with suddenness following increasing or newly won contracts, and in these and other circumstances their thinking is promoted by current technical literature and illustrations. The Authors have reason to believe that this source of initial contact is not sufficiently exploited, and, in view of the high ratio of industrial consumers to industrial gas engineers, there appears to be scope for a less abstract and more permanent type of publicity.

The industrial utilization of gas in the South Western Area, and some form of organization for its development, could no doubt be traced back to the very early days of our industry. This paper reviews only the period since vesting date, since which time reliable records for the whole area have been maintained. Our industrial sales for the past decade show a large though irregular expansive trend, as shown in Table 1 and its associated graph. The figures refer to a datum year, 1950-51 and indicate that, whereas total sales are now some 7·4 per cent below the datum figure, the industrial sales have increased by approximately 52 per cent. The graph indicates the erratic nature of the yearly industrial increases, but it is noteworthy that these increases were sustained in all cases except the year 1956-57.

If time and money were available one could, from research and analyses, obtain the chief variables affecting sales, and, also, their relative magnitudes. It is difficult to imagine, however, that the results of such a survey would uncover some untrodden avenue of approach or reveal a trend more diverse than existing knowledge and experience goes to show. In common with all Area Boards, the South Western Gas Board's industrial sales, existing and anticipated, hinge primarily on the following three factors:—

(1) The level and disposition of industrial activity.
(2) The impact of the gas industry's two major competitors, i.e., electricity and oil.
(3) The strength and the diversified efforts of the Board's sales organization.

The predominant factor is No. 1, over which one has no control. Factors 2 and 3 are the real and fundamental issues upon which the gas industry must increasingly focus its attention. They are inseparable factors, and the degree of control at any time exercised upon them will be a reflection of the industry's ability to make contact

with thermal problems as they arise and of its efficiency in dealing with them.

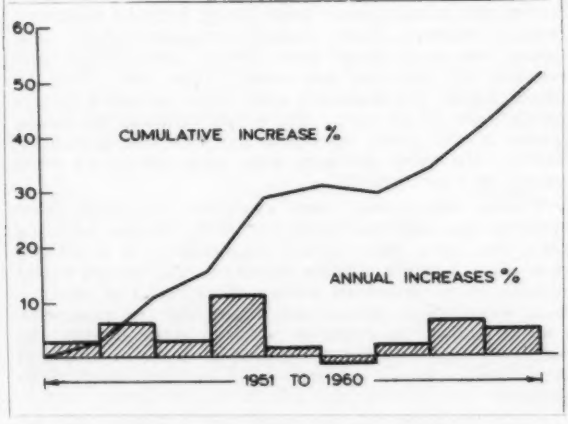
II ORGANIZATION

The Board's area covers 8,250 square miles and has a relatively low population density of 376/square mile. Only the Wales and Scottish Boards are below this figure. We can either boast or complain about boundless tracts of open forest and moorland, and much of the 400-odd miles of our coastline is unquestionably magnificent. The Area is unique in its attraction for tourists. All this reflects itself upon the Board's present position in the "industrial league table", where its figure of approximately 17½ per cent of total sales places it with the two other Boards of similar latitudes, i.e., looking up towards the remainder.

Of the Board's total industrial load, nearly 90 per cent is obtained from the concentration of industrial concerns within a radius of 50 miles of Bristol. The distribution of labour in the various industries within this radius is shown in Table 2, and from this it can be deduced that the total labour force in this region represents approximately 13 per cent of the gross population of the Board's area.

TABLE 1.—*Sales of Gas between 1950-51 and 1959-60.*

Year	Total Sales (1,000 Therms)	Industrial Sales	
		(1,000 Therms)	Increase (per cent)
1	2	3	4
1950-51	116,900	12,533	Datum
1951-52	114,233	13,016	3·85
1952-53	114,497	13,909	10·97
1953-54	113,508	14,451	15·30
1954-55	117,951	16,235	29·53
1955-56	114,123	16,517	31·78
1956-57	111,622	16,244	29·62
1957-58	112,247	16,761	33·72
1958-59	110,526	17,915	42·93
1959-60	108,274	18,968	51·88



Several of the Area's relatively large centres have not, as yet, gained industrial status commensurate with their populations. Plymouth, for example, has almost 250,000 people (about half the size of Bristol), and yet the industrial gas sales for the two cities are wholly incomparable. Again, Exeter has a greater population than either Swindon or Gloucester, but has only a fraction of the industrial activity in the two northern centres. In the environs of these fair cities, Plymouth and Exeter, there is tremendous capacity for industrial development, and in both cases the transport and other commercial facilities are excellent. It is obvious and natural enough that a strong resistance to industrial encroachment should exist in some sections of these areas, but this hardly constitutes a forward-looking policy.

TABLE 2.—*Distribution of Labour in Industry within a Radius of 50 miles of Bristol.*

	Industrial Category	Labour Force
1	2	3
1	Distributive trades	58,460
2	Aircraft, aero engines and repairs	47,190
3	Building and contracting	44,180
4	Transport, road, rail, sea and air	39,640
5	Engineering, machine tools, electrical equipment, marine	34,210
6	Food, drinks, bread and flour, confectionery, meat, milk, chocolate, cocoa, brewing	28,350
7	Vehicles : cars and motor-cyles, manufacture and repair	24,470
8	Paper and printing	23,570
9	Clothing	14,000
10	Chemical and allied trades	12,440
11	Gas, electricity and water	12,300
12	Woodwork and cork	9,670
13	Tobacco	7,500
14	Miscellaneous Industries : Rubber, leather lino sports equipment, stationery goods	6,670
15	Light metal products, brass nuts and bolts	6,090
16	Textiles, including carpets	5,970
17	Metal manufacture, iron and steel melting, rolling, tin-plate and sheet steel	5,600
18	Precision instruments	5,130
19	Mining and quarries	4,480
20	China, earthenware and glass	3,170

When one reflects on the Building (Industrial Premises) Regulations, the Factory Acts (a mere 150 Statutory Orders) and, more especially, upon the architects' cloister-like ability with single-floor factory layouts, the attitude, not of the community, but of the planners is all the more remarkable.

There are, however, signs of a "wind of change" in these regions, and it is worthy of mention that the very renowned firm of Smith's Crisps, Limited, whose product is relished by millions, has chosen Plymouth for one of its recent expansions.

In order to cover the technical and selling requirements for industry, there is now a fully operative South Western Gas Board Industrial Sales Organisation, which, although acting as a separate entity, is closely integrated in the over-all selling arrangements under the supervision of the Board's Area Development Manager. Throughout the Area, district industrial engineers are strategically disposed and are initially responsible to their respective District Managers. The location of industrial staff is as follows:—

Bath:	One industrial engineer. One industrial representative.
Bristol:	One senior industrial engineer. Four industrial engineers. One trainee.
Cheltenham:	One industrial representative.
Exeter:	One industrial engineer.
Gloucester:	One industrial engineer. One trainee.
Plymouth:	One industrial engineer. One technical assistant.
Swindon:	One industrial engineer. One trainee.
Taunton:	One industrial engineer. One technical assistant. One trainee.

TARIFFS

Price Area	Tariff Number	Gas Supplied (Therms/quarter, or part thereof): First 8	Next 92	Next 300	Next 600	Next 2,000	Next 2,000	Next 20,000	Next 25,000	Next 50,000	All over 100,000
1	2	3	4	5	6	7	8	9	10	11	12
						Pence/therm					
1	11	38·5	26·0	22·0	20·0	19·0	18·0	17·0	16·5	16·0	15·5
2	12	39·5	27·0	23·0	21·0	19·5					
3	13	40·5	28·0	23·5	21·5	20·0					
4	14	41·5	27·0	24·0	22·0	20·5					

Also, resident in Bristol, and directly responsible to the Area Development Manager, is the Area Industrial Engineer, who is consulted and advises on industrial gas affairs throughout the entire Area. His services are available for the design and development of prototype plant and equipment, and, under his direction, the services of a technical test engineer are constantly employed, wherever the survey and testing of existing gas-fired plant is considered to be of mutual interest for both the consumer and the Board. This relatively new extension of the Board's services to industrialists has effected much improvement in plant performance, created a lot of goodwill and provides a strong measure of support to our selling technique.

A much-welcomed augmentation of the Board's sales policy has been the new Industrial Showroom in Bristol. Here we have available, for working demonstrations, a small, but general, range of standard equipment, and, in the attached workshop, we are able to assemble special or prototype burner equipment on a limited scale. These facilities have already amply proved their need and we expect to see them extended so that, in line with other Boards' industrial development centres, we can accommodate the design and construction of larger and more complicated non-standard equipment to match the constantly recurring needs of industry's quest for change and improvement.

The current tariff is simple and operates to cover four price areas by a small differential.

III RECENT DEVELOPMENTS

In addition to the constantly increasing gas sales resulting from installations of standard or conventional equipment, the period since nationalization has seen many special and successful applications of the use of gas throughout the Area. Some have perhaps seemed unspectacular because of their apparently limited scope, while others, on account of their relatively smaller consumptions of gas, have passed into recognized use with little more than a brief mention during the course of an industrial engineers' meeting.

It is not the purpose here to define the Board's developments in its widest scope, i.e., what in the long term is the most remunerative load for the prior attention of the Industrial Department. In what follows, the Authors have attempted to outline developments that have shown enterprise and which are interesting as well as of substantial gas demands.

A shown in Table 2, the aircraft and allied industries occupy a leading place in manpower requirements, and their status with regard to gas consumption is rather similar. Of the Board's total industrial load, this industry accounts for 10 per cent, approx. It is not, therefore, unexpected that the Board has been able to identify itself to some extent with the vast programmes of research and development in the aircraft and allied industries.

NORMALAIR LIMITED, YEOVIL

During 1956, this firm was progressively increasing test facilities at its high-altitude Laboratories in Yeovil. Included in their research equipment are numerous decompression chambers, the largest of which is capable of accepting aircraft specimens containing the complete aircraft air-conditioning and pressurization system. These systems are tested in the chambers under artificially reproduced and carefully controlled conditions of flight.

In the aircraft during flight, the air supply to these systems is obtained by means of engine-driven blowers or by tapping the main engine compressor. This is delivered to the cabin at high pressures and temperatures due to " ram " effect and the mechanical compression. It became necessary to reproduce these conditions of pressurized air at elevated temperatures, and during early 1956 this firm requested from the Board's Area Industrial Department a design of a town gas/air heat exchanger suitable to the firm's specific requirements, chiefly as follows :—

(1) Delivery of clean air at mass flows up to 58 lb/min.
(2) To be capable of withstanding air pressures up to 250 lb/in.^{2} gauge.
(3) Maintenance of maximum air flows at temperatures up to 1,100°F.

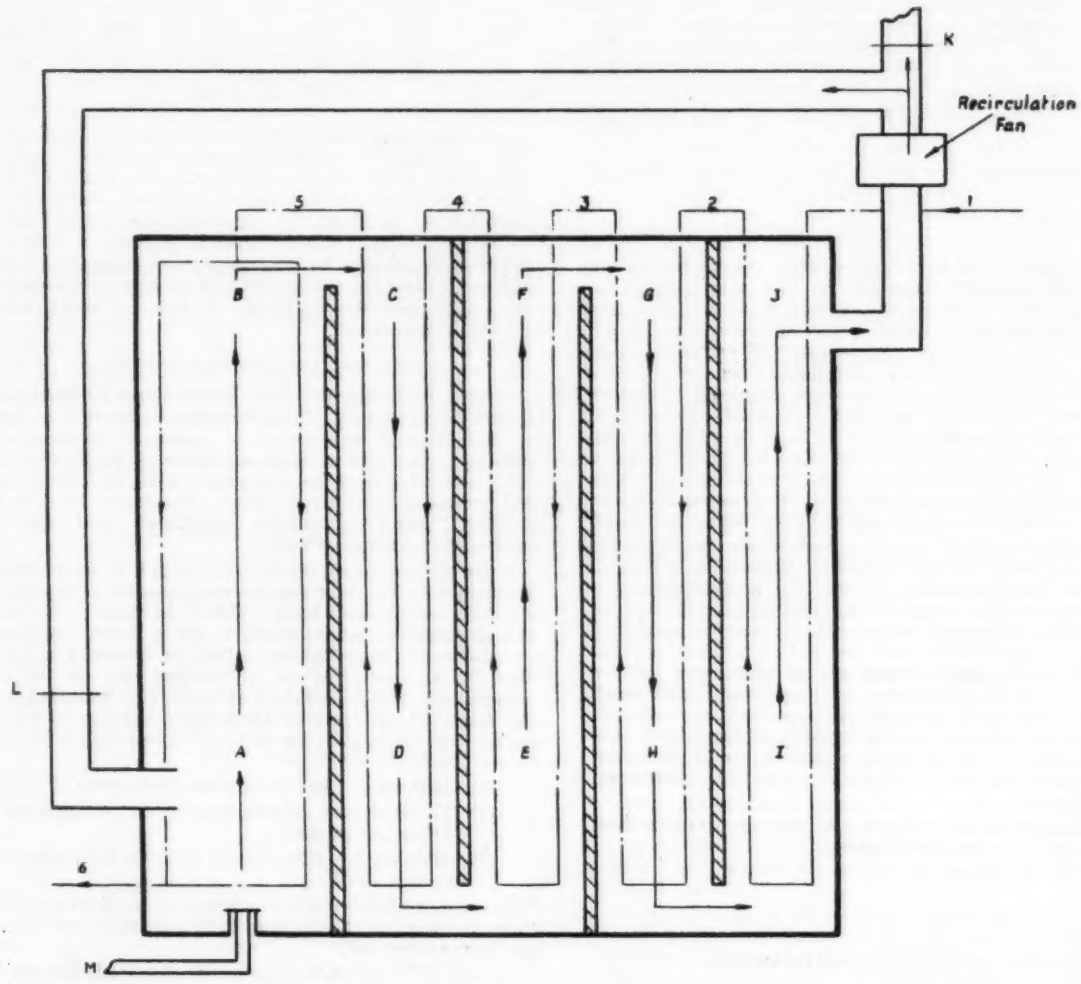
This was considered a unique application, as there appeared to be no record of similar plant in this country operating on gas or any other fuel.

In early 1957, the plant to be briefly described, designed by the Board's Area Industrial Department, and constructed by Industrial Furnaces, Limited, was commissioned for use and has since then become an integral part of Normalair's research programme.

Description of Plant

This heater is a compact sheet steel-clad furnace, suitably lined with refractories and divided into a combustion chamber and four heating zones by refractory walls having alternate upper and lower connecting passages. Overall dimensions are :—Length, 10 ft 8 in., width 4 ft 8 in., and height 10 ft 2 in.

The hot combusted gases flow alternately upwards and downwards throughout the length of the heater and finally enter the recirculating fan, which returns the hot products to the combustion chamber. A flue is connected to the fan outlet for the necessary effluent gas spillage. High-pressure air enters at the outlet gas zone *via* a 4 in. diameter header, and, extending from this, a hairpin arrangement of tubes traverses the air through this zone and terminates in a similar header at the top of the next adjacent zone. The air flow



—→Hot gas flow. —.— Air flow.

Air Temperatures (°C)

1	Inlet to Heater Zone 4	19°	4	Outlet of Zone 2	350°
2	Outlet of Zone 4	130°	5	Outlet of Zone 1	
3	Outlet of Zone 3	220°	6	Outlet of Heater	593°

Gas Temperatures (°C

A	Combustion Chamber—Lower	610°	H	Zone 3—Lower	250°
B	Combustion Chamber—Upper	620°	I	Zone 4—Lower	225°
C	Zone 1—Upper	600°	J	Zone 4—Upper	190°
D	Zone 1—Lower	430°	K	Main waste gas damper	187°
E	Zone 2—Lower	420°	L	Recirculation gas inlet	185°
F	Zone 2—Upper	330°	M	Gas/Air mixture inlet	
G	Zone 3—Upper	320°			

FIGURE 1.—*Diagrammatic Flow Pattern of an Air Heater.*

progresses through each heating zone in the same tube and header arrangement until the combustion chamber, where the tubes follow the walls, roof and floor ; the processed air is finally collected in an external header leading into the delivery control system. The tubes (1¼ in. o.d. × 10g) and the headers are of stainless steel. A diagrammatic outline of the heater is given in Figure 1.

Gas Supply and Control Equipment

Low-pressure gas, *via* the governor, main and by-pass magnetic valves, passes to a single " Hypact " burner fitted vertically through the combustion chamber floor. Flame-failure protection is provided by means of the Ether Wheelco Flame-Otrol equipment, using flame conductance from a pilot jet to the electrode. This arrangement can be seen in Figure 2.

The control panel consists of the following instruments :—

(1) An air-temperature indicator with a pre-set control needle that cuts out the main magnetic gas valve when the desired temperature has been reached.
(2) Combustion-chamber temperature indicator.
(3) Air-pressure switch in circuit with the main and by-pass magnetic valves, which prevents gas passing to the burner until the air-flow pressure has reached 20 lb/in².
(4) Exhaust-fan control switch with three positions :
  (*a*) Normal running : gas passing to burner.
  (*b*) Stop : gas cutting out with the fan.
  (*c*) Purging : fan working, but no gas passing to burner.

  The latter position is used for purging the furnace atmosphere prior to starting up the plant.
(5) Pressure gauges :—
  (*a*) Working gas pressure (in. w.g.).
  (*b*) Air pressure in tubes (lb/in.²).
  (*c*) Exhaust fan, pressure (in. w.g.).

Operation

No gas can reach the burner until all the following conditions have been obtained :—

(1) Exhaust fan working.
(2) Pilot light established.
(3) Air mass flow at 20 lb/in.² gauge.

Control of temperature is effected by means of the indicator/controller. Until the preselected temperature is reached, both the main and by-pass magnetic valves are open and the full gas rate is passing to the burner. At the selected temperature, the main magnetic valve closes and a panel light indicates this operation. Thereafter, the main magnetic

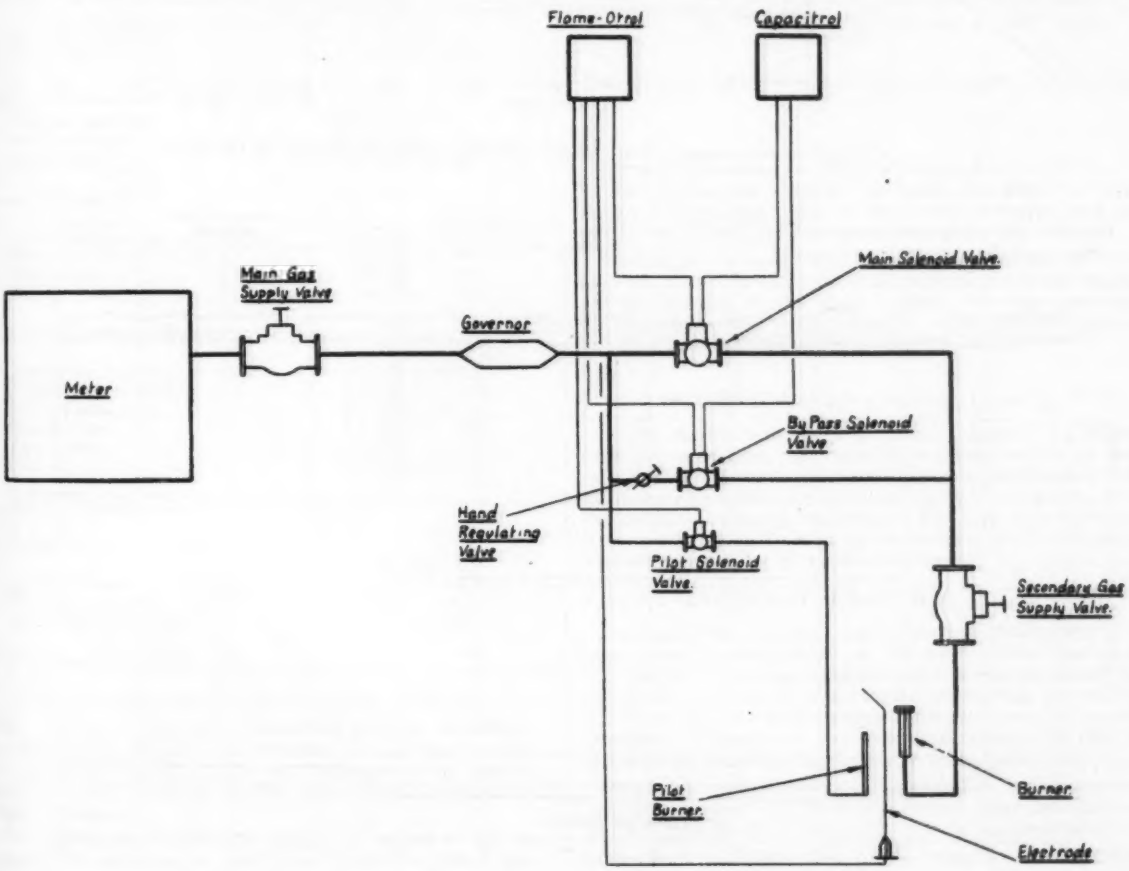


FIGURE 2.—*Diagrammatic Arrangement of Flame-failure Control Equipment.*

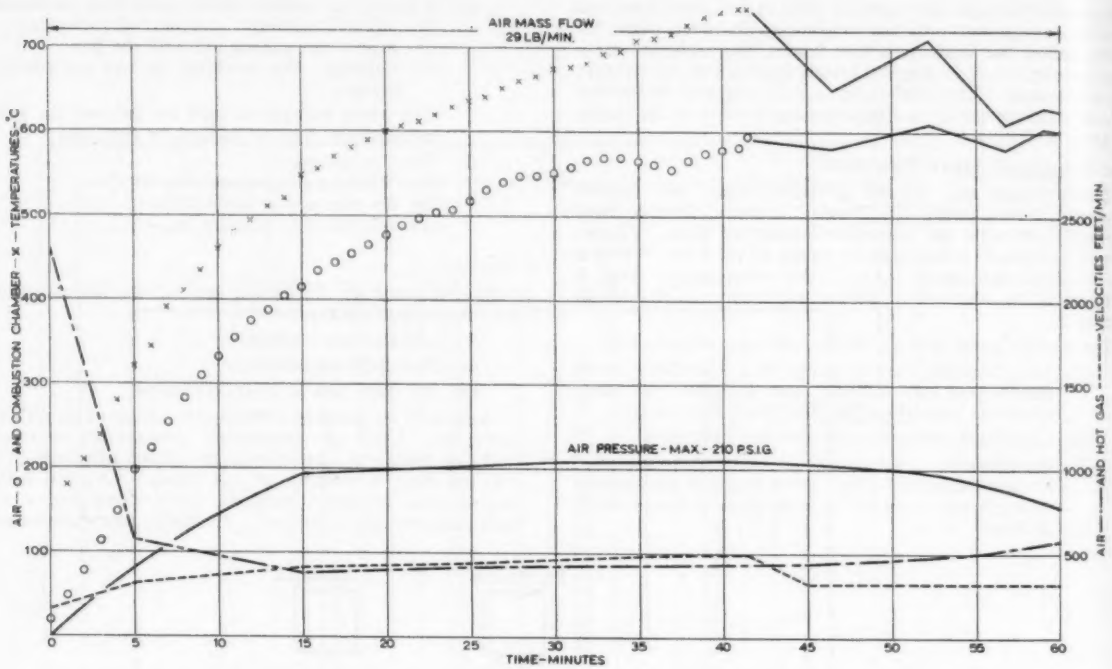

AIR MASS FLOW
29 LB/MIN.
AIR PRESSURE - MAX - 210 P.S.I.G.
AIR — O — AND COMBUSTION CHAMBER — x — TEMPERATURES °C
AIR —— AND HOT GAS ------ VELOCITIES FEET/MIN
TIME-MINUTES

FIGURE 3.—*Performance of Air Heater with Maximum Air Pressure of* 210 *lb/in*^{2}.

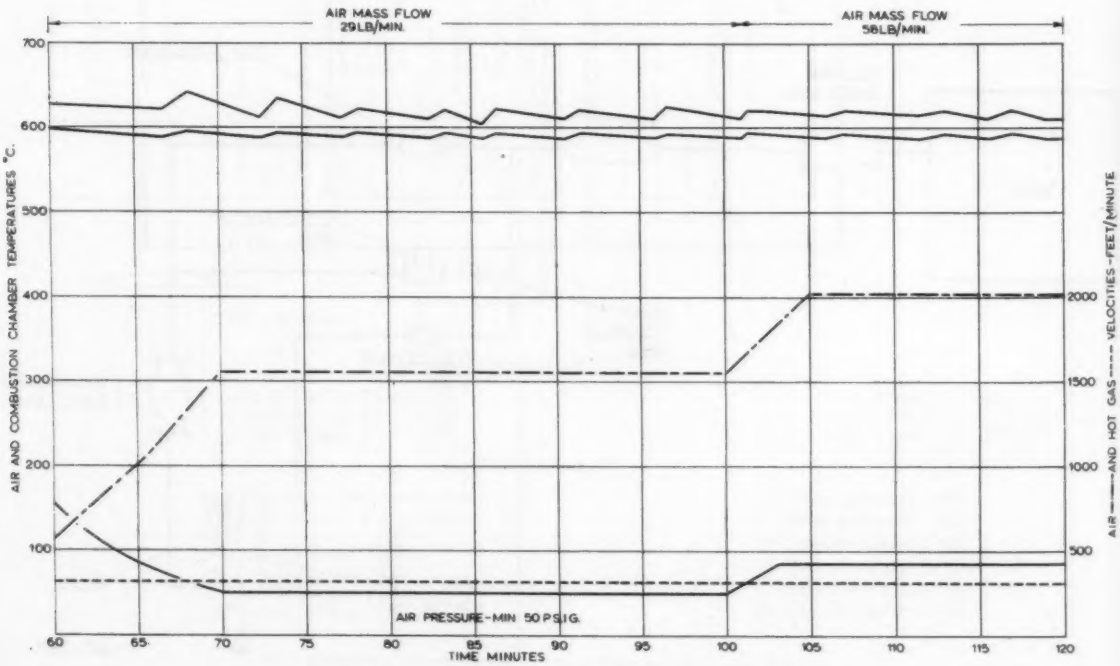


FIGURE 3a.—*Performance of Air Heater with Minimum Air Pressure of* 50 *lb/in*^{2}.

valve opens or closes with variation of outlet air temperature. The amount of gas passing through the by-pass valve is adjustable ; adjustment to this may be necessary to suit low temperature and air flow conditions.

Normalair, Limited, has installed, downstream of the heater, air-mixing control equipment. This enables the temperature of the air mass flow to be varied to suit the test-rig experiments, irrespective of constant conditions being maintained at the outlet of the heater.

Plant Performance Data

The first official performance test took place on 14th February, 1957. The primary objects of this test were as follows :—

(1) To obtain a representative curve for the " heating-up " period, starting from cold conditions.
(2) To observe and record the temperature of the combustion chamber and the outlet air under varying conditions of air mass flow and air pressure.
(3) To ascertain the cooling rate with gas cut off.
(4) Thermal efficiency.

Graphs for the plant performance are given in Figures 3, 3*a* and 3*b*. Air and gas velocities are shown in Figures 4, 5 and 5*a* and Figure 6 deals with hot gas recirculations.

Heating rate from cold conditions to 1,100°*F* (593°*C*) :

°F/min. (average)	25·0 (13·9°C.)
Air Mass Flow	29·0 lb/min.
Air pressure	210·0 lb/in² gauge.

Cooling rate from 1,100° *to* 520°*F* (593° *to* 271°*C*) :

°F/min. (average)	20·7 (11·5°C)
Air Mass flow	58·0 lb/min.
Air Pressure	85·0 lb/in² gauge.

Thermal Balance :

		Per cent
Gross average heat input (Btu/h)	1,295,800 =	100·0
Heat transmission to air (,,)	899,500 =	69·4
Flue losses (,,)	309,700 =	23·9
Surface losses (,,)	86,600 =	6·7

Heat Transmission Distribution :

		Per cent
Total heat transmission (Btu/h)	899,500 =	100·0
Combustion Chamber (,,)	176,200 =	19·59
No. 1 Zone (,,)	223,400 =	24·83
No. 2 Zone (,,)	197,900 =	22·00
No. 3 Zone (,,)	134,900 =	15·00
No. 4 Zone (,,)	167,100 =	18·58

Overall heat transfer coefficient : 8·3 Btu/ft²/h/°F

Waste gas analysis, dry basis :

	Per cent
Carbon dioxide	6·0
Oxygen	10·8
Nitrogen	83·2

Hot gas recirculation ratio : 2·2

ROTOL AIRSCREWS, LIMITED, CHELTENHAM

Prior to the completion of the above plant at Normalair, interest in these facilities was mounting and, following upon an enquiry by the Area Industrial Engineer to the firm of Rotol Airscrews, Limited, the Board was quickly engaged on a similar project.

The requirements here were similar in respect of the air temperature and pressure, but a much greater air mass flow was involved, namely 2·5 lb/s, as against the 1 lb/s, for the Normalair plant.

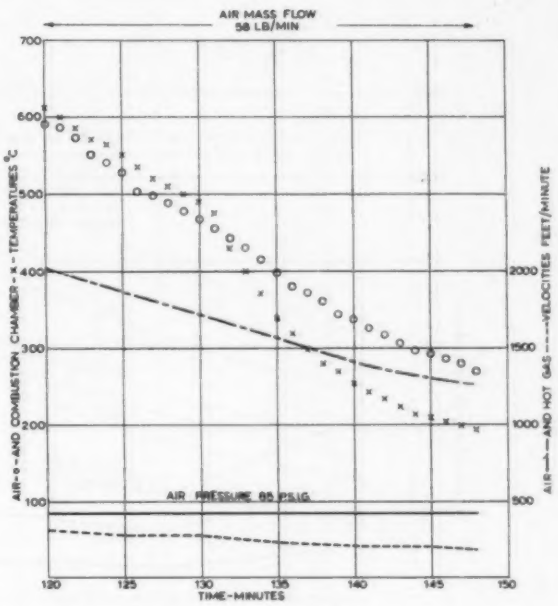


FIGURE 3*b*.—*Performance of Air Heater with Air Pressure of* 85 *lb/in²*.

Some improvement in design technique led to a reduction in the relative size of plant ; generally, however, the main design features were based on the earlier prototype, and the system of control and instrumentation was fairly identical.

This plant was commissioned during the summer of 1957 and was soon fully operative as an integral part of the special testing facilities of this firm. Later, following increased demand for testing, an additional air heater was installed by Gibbons Brothers of Dudley.

BRISTOL-SIDDELEY ENGINES, LIMITED

At the Patchway works of the above company, our efforts have for some time past been concentrated mainly on two special divisions where projects offered opportunities both of increasing existing gas loads and also obtaining new ones. In view of the apparent limitless scope for high-duty materials, these two divisions, the Ram Jet Department and the Precision Foundry are worthy of special mention.

RAM JET DEVELOPMENT DEPARTMENT

Alongside the numerous and important development projects already commissioned on this site, a further feature of the intensity of the company's research work has been in the design and installation of an engine combustion research rig for work on the thermodynamic and aerodynamic research problems in connexion with the maintenance of efficient combustion and heat transfer within a ram jet engine.

With the progressive development of higher-powered engines, the need has arisen to simulate flight conditions at speeds up to Mach = 4·0, i.e., four times the speed of sound.

In order to achieve this, it was necessary to incorporate in the above combustion rig some form of heat exchangers capable of raising the engine air supply temperature to 650°C.

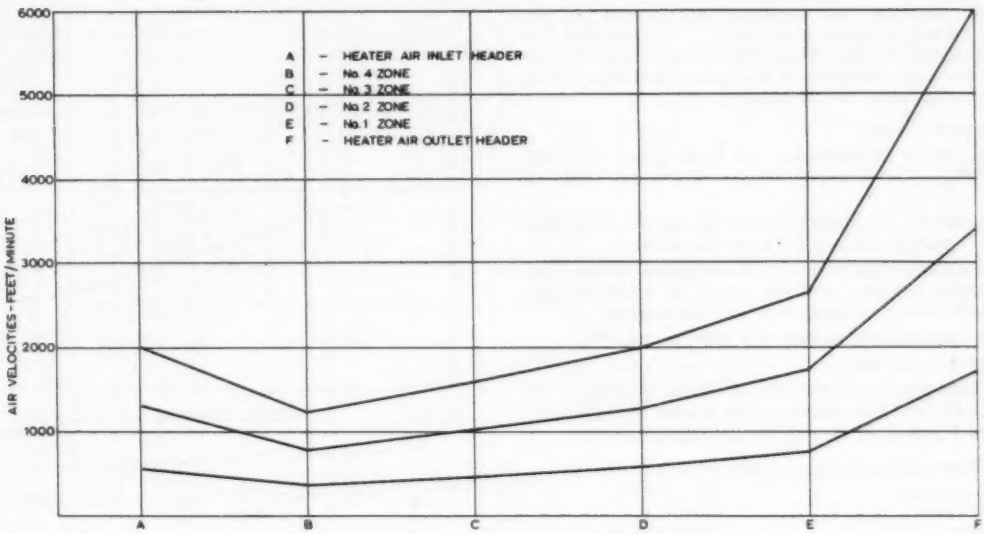


FIGURE 4.—*Air Heater Zonal Air Velocities at Various Air Pressures.*

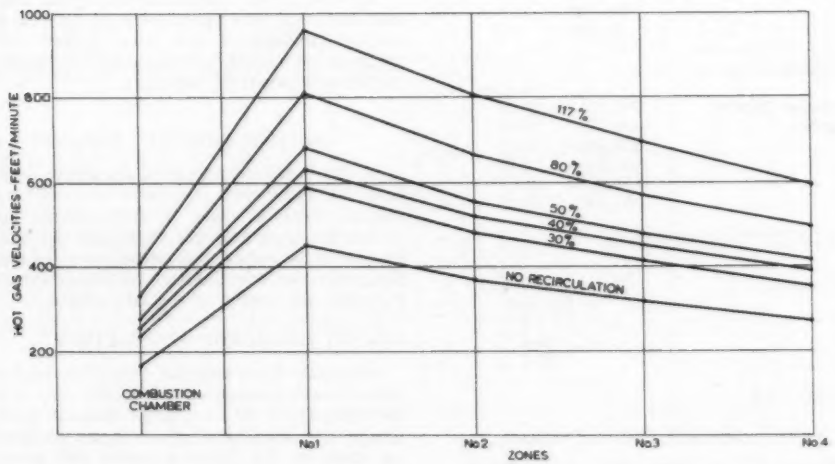


FIGURE 5.—*Hot Gas Velocities in Combustion Chamber and Zones at Various Percentages of Recirculation.*

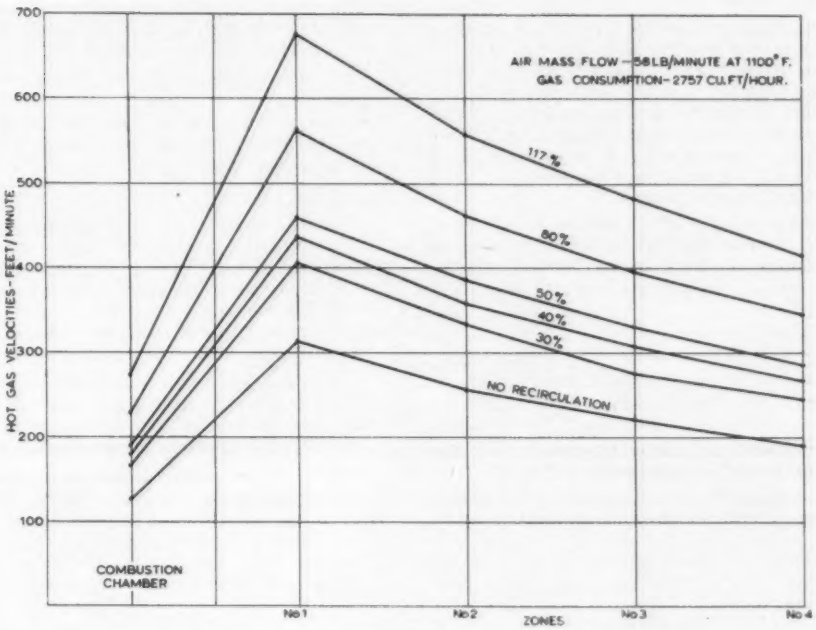


FIGURE 5a.—*Hot Gas Velocities in Combustion Chamber and Zones at Various Percentages of Recirculation.*

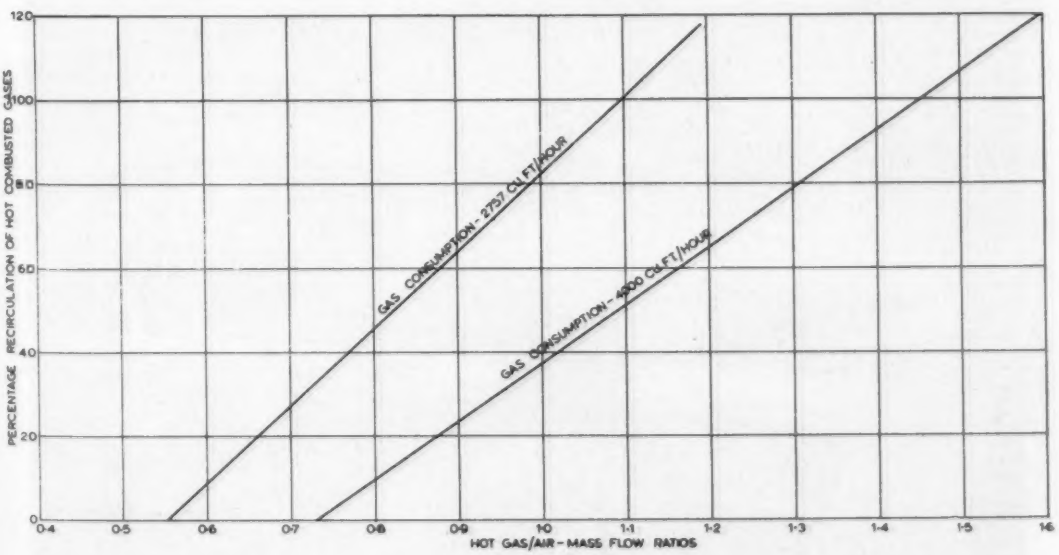


FIGURE 6.—*Percentage Recirculation of Hot Combusted Gases at Two Rates of Gas Input to an Air Heater.*

This temperature represents the ambient temperature at the engine intake at Mach = 4·0.

In addition to combustion research work, such facilities as the above rig affords now include full-scale testing of engine components, e.g., air-driven, turbo fuel and hydraulic pumps. All these can be submitted to realistic environmental tests covering bearing life, fatigue of turbine rotors and other highly stressed components at elevated temperatures. Also, the behaviour of fuels, response rates of servo mechanisms and all manner of sundry investigations necessary to ensure the reliability of Bristol-Siddeley ram jets.

During negotiations, early in 1959, for the provision of suitable gas-fired equipment, the Test Facilities Department of Bristol-Siddeley Engines, Limited, specified certain stringent requirements of the plant to be designed, and most important were the following :—

(1) Delivery to the Company's pilot test combustion rig of clean air at mass flows up to 600 lb/min.

(2) This delivery to be made at pressures up to 200 lb/in.^{2} gauge, and maintained at temperatures up to 650° C.

(3) The plant should be capable of maintaining deliveries down to 60 lb air mass flow/min. at 120° C.

An important new aspect had now arisen in the development of air heaters, namely, the air mass flow requirement at 10 lb/s was four times the amount necessary for the previous plant at Rotol, Limited. This obviously involved design economy, and a fresh approach to the layout of the heat transfer tubes was studied.

It was finally decided that the air heater plant should comprise of two separate units of equal capacity (i.e., each to deliver 300 lb/min. air mass flow) and that either one or the two units in combined operation would satisfy these demands.

In co-operation with the South Western Gas Board's Area Industrial Engineer and the Gas Council's West Midlands Research Station, the plant was designed and manufactured by Industrial Furnaces, Limited, Kingswinford, Staffs. (See Figures 7 and 8.)

Description of Plant

The two heaters are identical, having overall dimensions 4 ft 6 in. diameter and 14 ft high. The combustion system comprises three high-velocity air blast tunnel burners firing downwards through a central combustion chamber lined with stainless steel tubes. At the base, the hot gases are diverted upwards through a special tube system and, at the uppermost section, are ejected to atmosphere.

The high-pressure air is admitted *via* a top inlet header and passed downwards through the outer special tube system and then upwards through the stainless steel tubes, and is finally collected in the outlet high-temperature header.

At the base, an intermediate header changes air direction from downward flow (outer tubes) to upward flow (stainless steel tubes) and has special characteristics for allowing expansion due to heat and shock, changes of air flows and pressures. (See Figure 8*a* for the section through the heater.)

Gas is supplied to each heater through a 6 in. zero governor, and then, from a common manifold, the supply to each

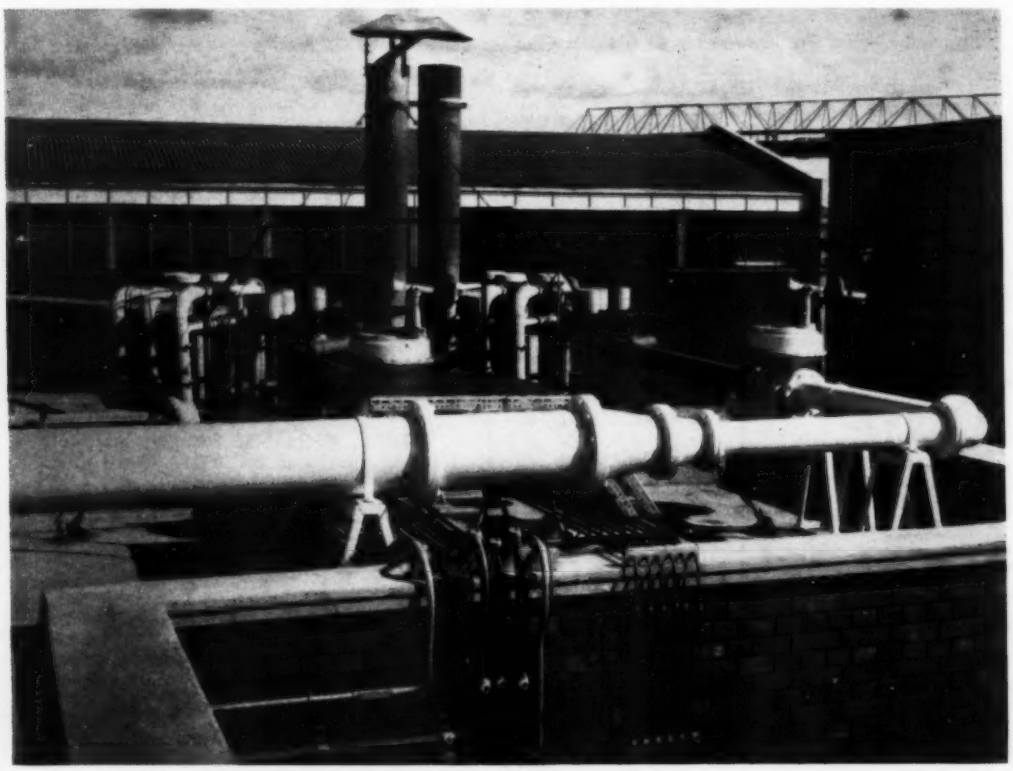


FIGURE 7.—*Air Heater Installation at Bristol-Siddeley Engines, Limited, Patchway, near Bristol.*

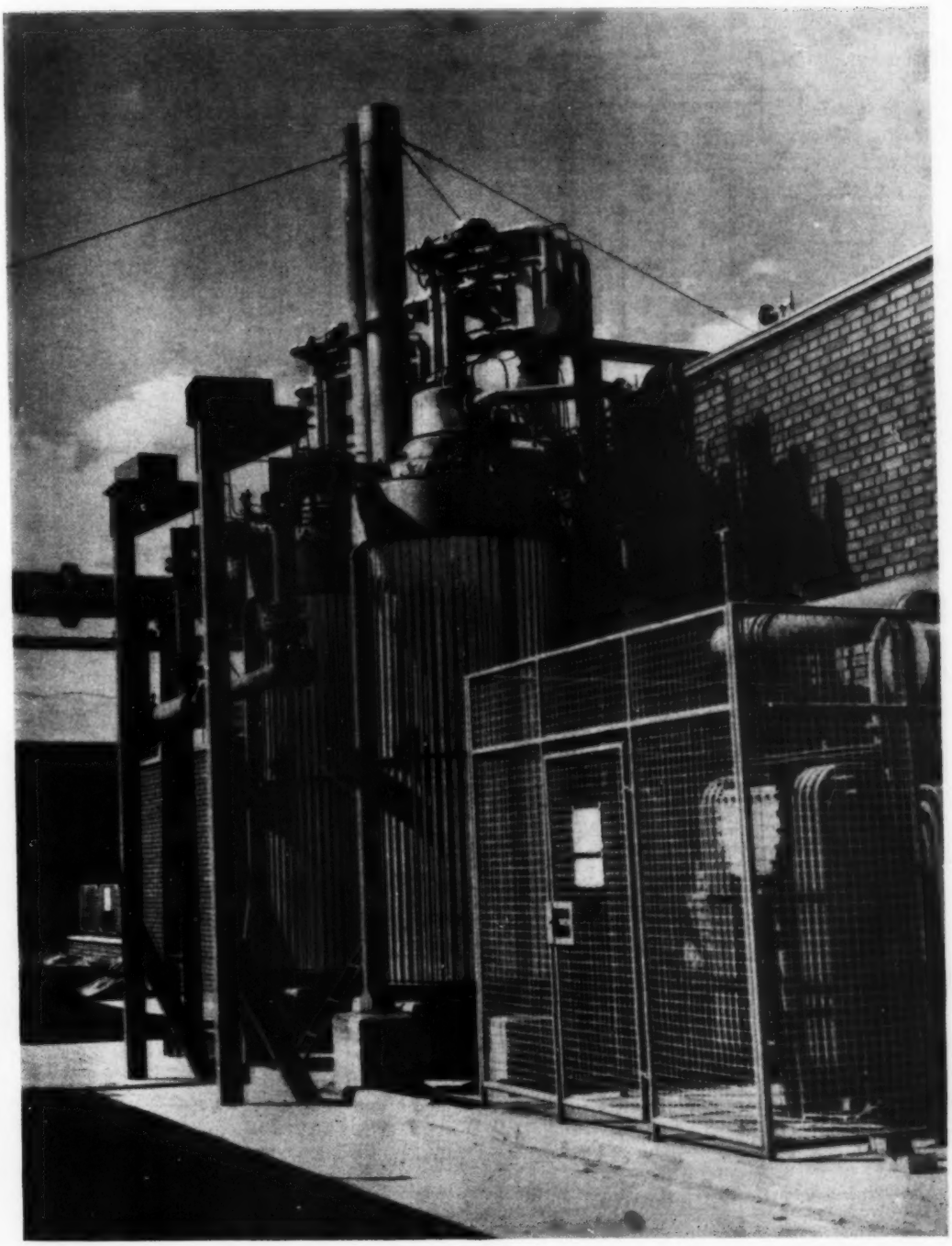
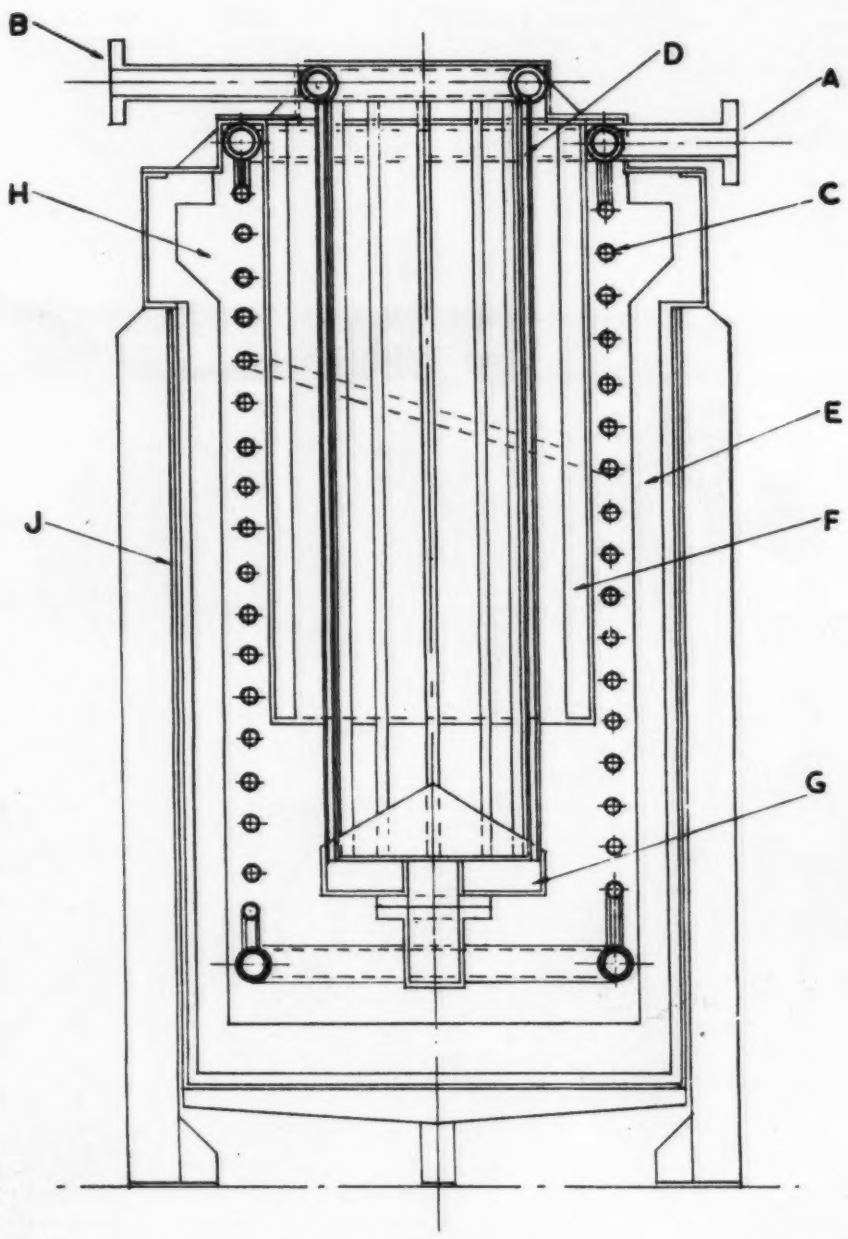
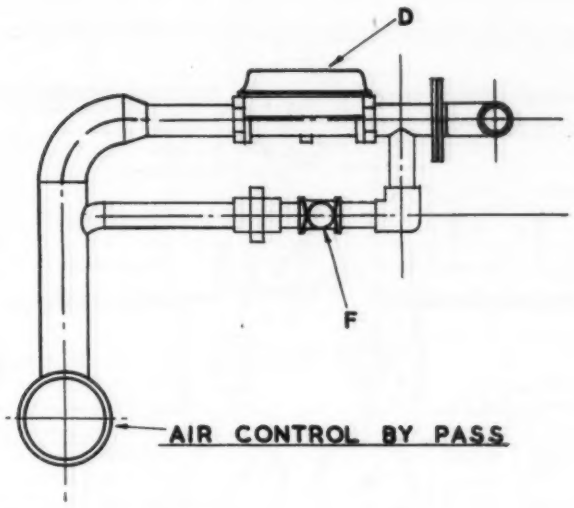


FIGURE 8.—*Air Heater Installation at Bristol-Siddeley Engines, Limited, Patchway, near Bristol.*



A—Process air inlet.
B—Process air outlet.
C—Low-temperature coil.
D—High-temperature coil.
E—Insulative lining.
F—Refractory-lined baffle.
G—Intermediate header.
H—Gas collector chamber.
J—Steel casing.

FIGURE 8*a*.—*Section through Type R.T. Air Heater.*



A. Town gas from zero governor
B. Gas Solenoid Valves
C. Flame failure detector cells
D. Air control valve
E. Fan
F. Air Bypass valve.

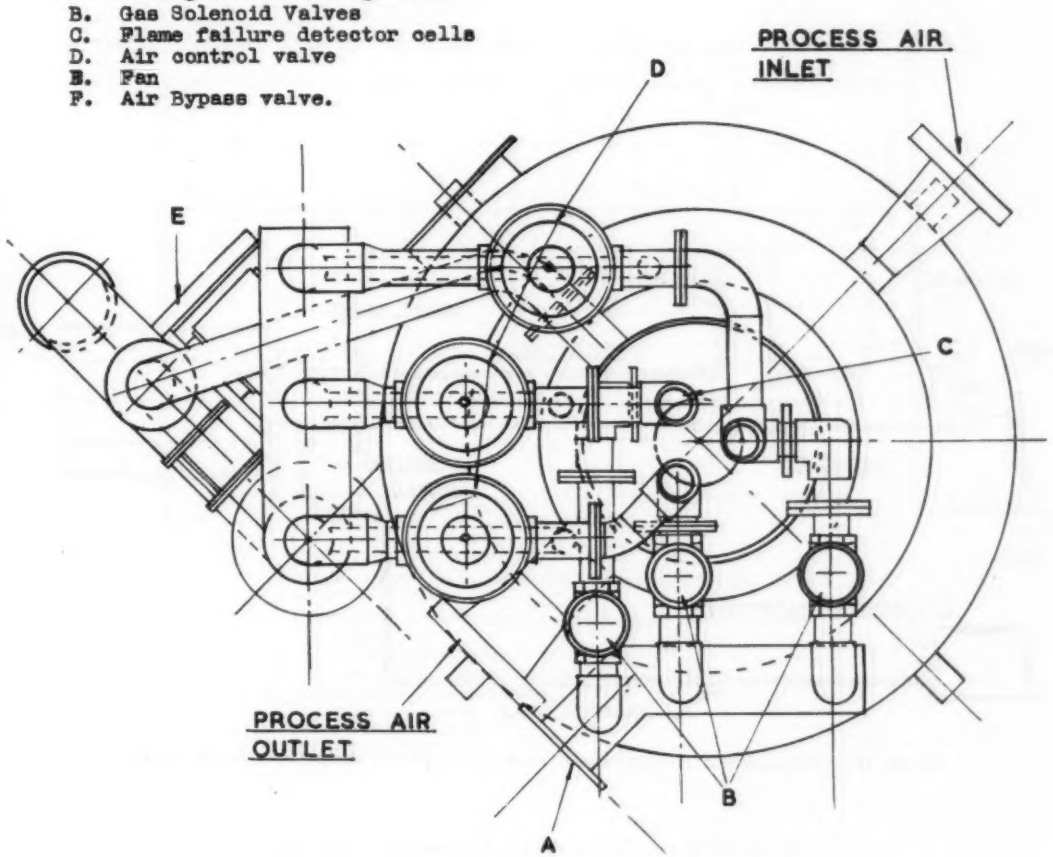


FIGURE 9.—*Plan of Gas and Air Pipework for Air Heater.*

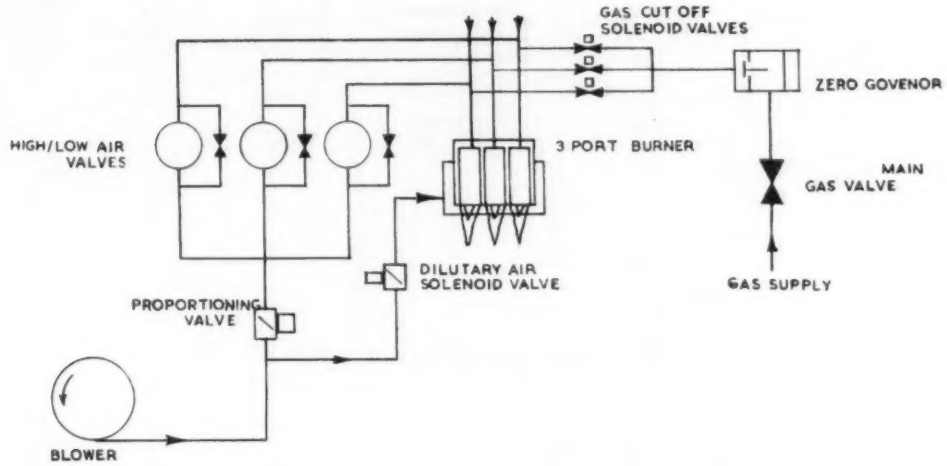


FIGURE 9a.—*Schematic Arrangement of the Combustion System for Type R.T.6 Gas-fired Air Heaters.*

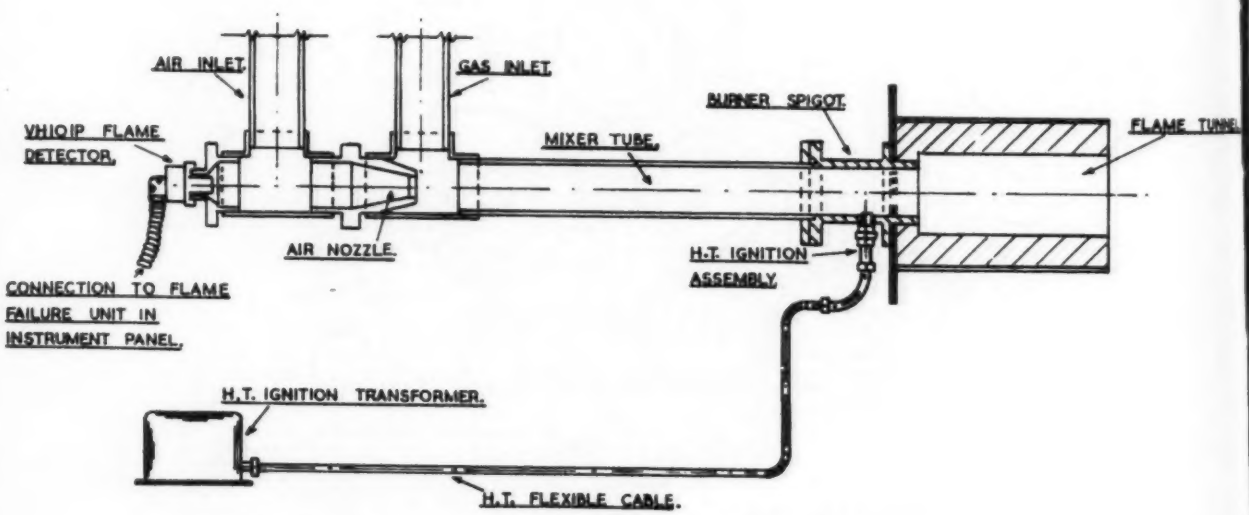
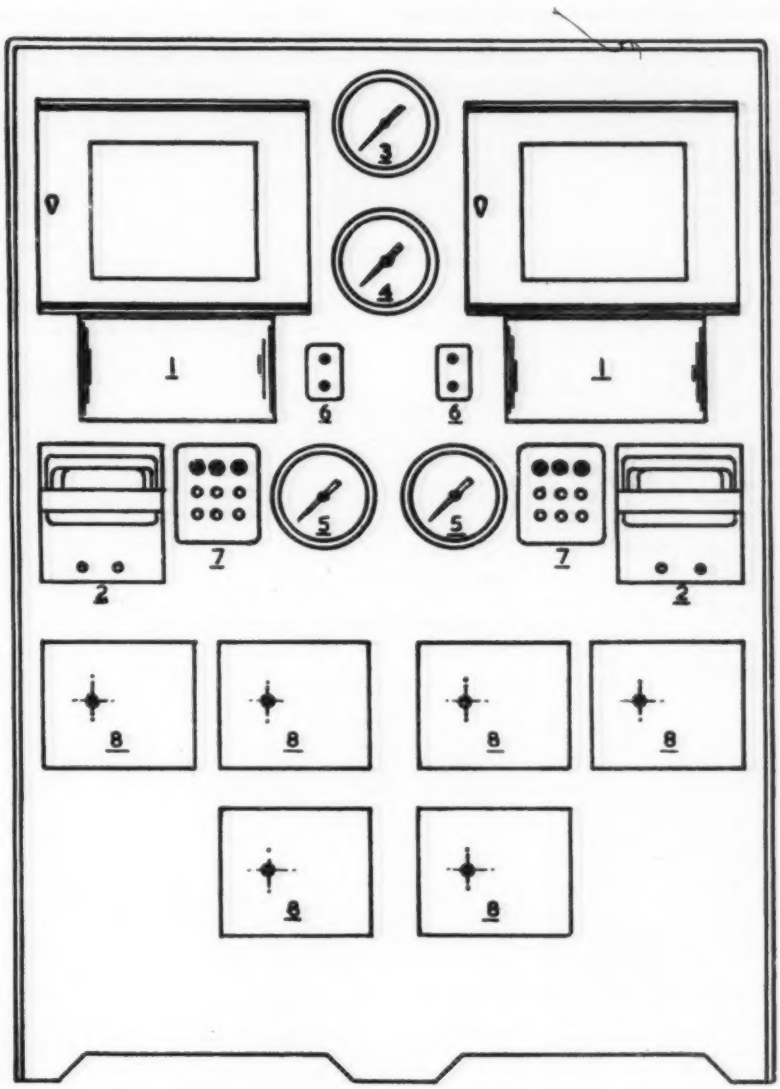


FIGURE 10.—*Diagrammatic Arrangement of Ignition and Flame-failure Units for Gas Burner.*



1 "Strip chart" air temperature controller. (Range : 0 to 800°C.)
2 Combustion temperature controller and cut-off. (Range : 0 to 1,600°C.)
3 Process-air pressure gauge. (Range : 0 to 200 lb/in².)
4 Gas main pressure gauge. (Range : 0 to 12 in. w.g.)
5 Combustion-air pressure gauge. (Range : 0 to 50 in. w.g.)
6 Fan start/stop control.
7 Burner-selection control.
8 Flame-failure units.

FIGURE 10*a*.—*Instrument Panel Layout for Type R.T.6 Air Heaters.*

burner is induced through separate restrictors and solenoid valves.

Medium-pressure fan air connected to each burner is separately controlled by both solenoid-operated relay valve and adjustable by-pass arrangement. The air is discharged into the mixture tube through an orifice, thereby inducing gas *via* the zero governor and restrictor and resulting in almost stoichiometric conditions at all rates of flow. (See Figure 9 for a plan of gas and air pipework, and Figure 9*a* for the schematic arrangement of the combustion system.) The control equipment includes the following :—

(1) A strip chart indicating temperature controller sensing from a thermocouple positioned in the air outlet header and operating with the proportioning valve in the combustion air supply to the burners.

(2) An indicating temperature controller sensing from a thermocouple positioned in the combustion chamber. This control operates a gas cut-off in the event of overheating.

(3) An electronic programming unit for each burner.

(4) Flame-failure protection is provided by a lead sulphide-type sensing cell fitted at the head of each burner. (See Figure 10 for the arrangement of the ignition and flame-failure equipment, and Figure 10*a* for the instrument panel layout.)

Pre-commissioning trials were carried out during the week ended 30th April, 1960, and representative curves for the heating up period are given in Figures 11 and 12.

Figure 13 shows the control panel. Gas flow rates are shown in Figure 14.

Further proving trials have been satisfactory and the plant is now fully commissioned and in use.

During the final stages of the above installation, the Ram Jet Department made known its future requirements for high-temperature air in connexion with hypersonic flight problems. In consequence, Bristol-Siddeley Engines Test Facilities put out a specific enquiry for a heat exchanger to supply a mass flow of 10 lb/s at 300 lb/in.^{2} gauge and at 1,700°C. This temperature far exceeds the material limits of conventional heat exchangers, and attention was therefore focused on a pebble heater. Since then, the firm of Industrial Furnaces, Limited, in co-operation with the Board's Area Industrial Department and the Gas Council's Research Station, has put forward the basis and a quotation for the design and installation of a regenerative-type pebble-bed heater. A brief outline of this is shown in Figure. 15

The heating cycle is a " down run " with the gas burner at the top, water-cooled and firing either tangentially or directly downwards into a combustion chamber. Preheat for the combustion air will be provided externally. The hot gas

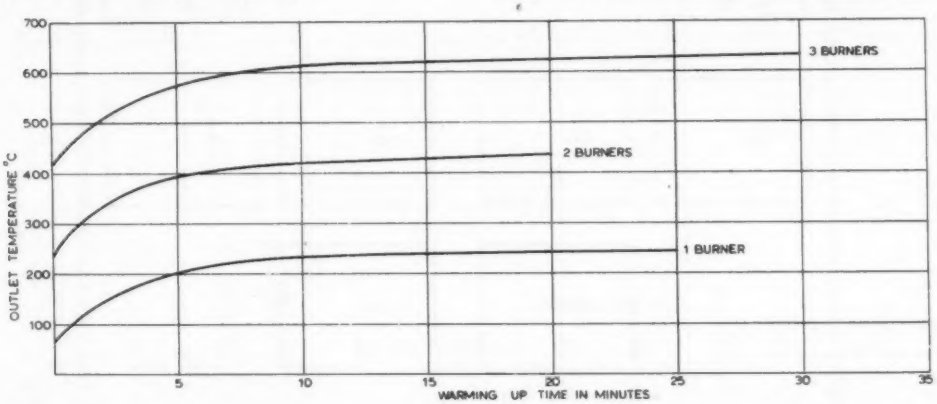


FIGURE 11.—*Graph of Outlet Air Temperature/Warming-up Time for No. 2 Heater for an Air Mass Flow of 5 lb/s.*

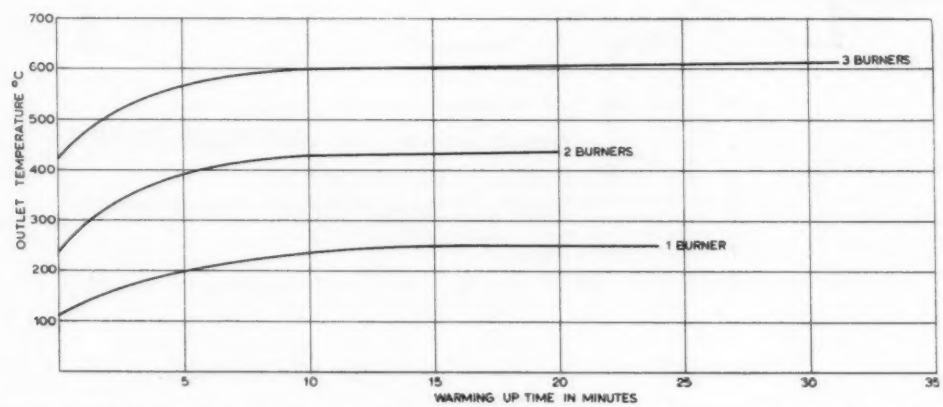


FIGURE 12.—*Graph of Outlet Air Temperature/Warming-up Time for No. 1 Heater for a Mass Flow of 5 lb/s.*

FIGURE 13.—*Control Panel for Air Heater.*

down run may be of several hours' duration. Pressure air will then be admitted at the base, and the process air cycle, which will be an " up run ", may only continue for about 10 min. The temperature gradient from the combustion chamber to the support grate or arch is likely to be of the order 1,800° to 600°C, and the refractory materials for the heater inner lining and the 1½ in. diameter pebbles will be correspondingly graded from pure alumina bricks at the top to 42 per cent alumina bricks at the grate.

Among the many fresh problems encountered with a project of this nature is that of assessing reliable design heat transfer coefficients. Although much data are available on this subject for packed beds, they are known to spread over two orders of magnitude for any one Reynolds number value. In this connexion, some recent experimental work* carried out at the Lewis Research Centre of N.A.S.A., Cleveland, Ohio, has been reported and includes useful heat transfer data based on working results.

PRECISION FOUNDRY INVESTMENT CASTING

The change from piston engines to turbines required new techniques in the manufacture of turbine blades and housings, which require intricate shapes cast in new materials capable of meeting the temperatures and stresses encountered in modern engines.

The investment casting technique, sometimes referred to as the " lost wax " technique, of casting made its industrial debut in this country some 20 years ago, in the production of aircraft engine component parts. It is now well established and recognized by engineers as yet another production process with which complicated shapes can be made and affording considerable scope to the designer.

Briefly described the process commences with :

(1) The manufacture of a die containing the negative shape of the pattern from which the expendable patterns are produced. Steel or aluminium machined dies give the highest accuracy in the expendable pattern, and maximum die life. Cast dies have some advantages and the material found most suitable for these is the Bismuth-alloy series.

(2) From the die, expendable patterns are produced. The material used is a composition of paraffin and carnuba waxes with flexoresin. The heated wax is injected to the die by machines having high (500 lb/in.² gauge) and low (80 lb/in.² gauge) pressure systems.

(3) Patterns thus produced then move to the assembly or clustering stage. This entails joining a number of patterns to a main runner and fixing a feeder gate.

(4) The completed wax assembly receives its primary investment by immersion in a slurry of bonded refractory material, and is then suspended from a

* *N.A.S.A. Technical Note TND-265* Lancashire, R. B., Lezberg, E. A. Morris, J. F.

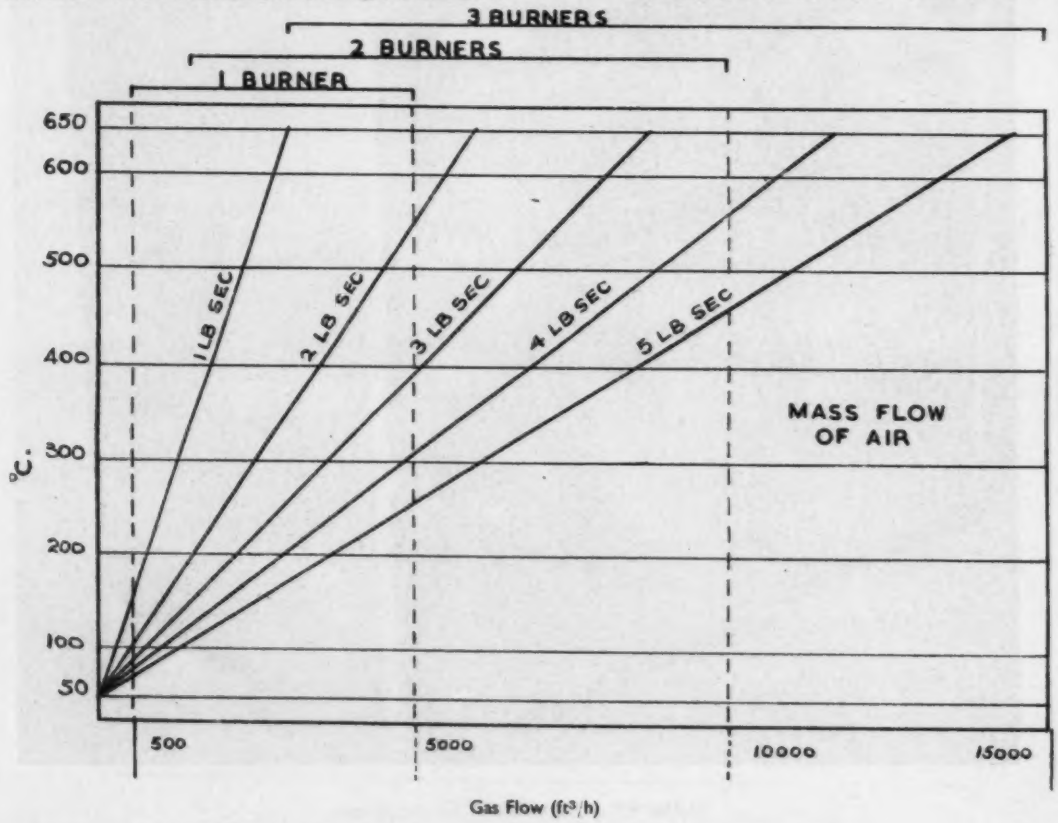


FIGURE 14.—*Burner-application Graph for Type R.T.6 Gas-fired Air Heaters.*

vibratory unit, and, while still moist, is given a further coating or spray of coarse refractory material.

(5) Then follows next the secondary investment, where the coated wax assembly is placed in a moulding-box on a vibratory table, and a travelling mixer discharges the investment around the assembly.

(6) Low-temperature mould drying and removal of wax pattern.

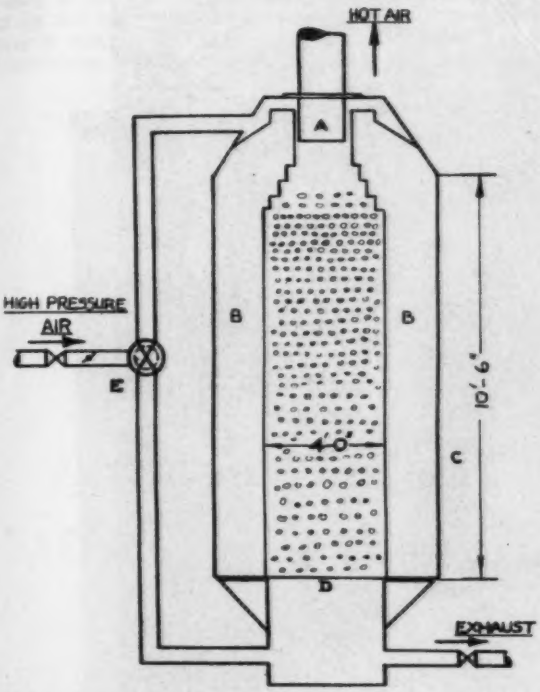
(7) The mould is now fired for a predetermined period at around 1,050°C.

(8) Casting takes place as the mould is withdrawn from the firing furnace.

(9) Finally, fettling and inspection of the cast component.

In Figures 16, 17 and 18, some of the stages of the process are clearly shown. It is, of course, with items 6 and 7 of the foregoing that gas plays a prominent part, i.e., the low-temperature drying or " melt-out " of the wax pattern and, later, the firing and " burn-out " of the mould.

Originally, the low-temperature operation was carried out by means of indirect-fired high-pressure air-circulation ovens. As a result of constant laboratory research and experimentation, a further development to emerge in the investment field has been the refractory-shell technique of mould production. In the process, the " melt-out " of the expendable pattern takes place immediately following the primary coating or investment, and, consequently, the primary coating is repeated several times until a shell thickness of $\frac{1}{4}$ in. is obtained. The heat requirements for removal of the wax pattern could not now be satisfied by the air-circulation ovens. Some means of heating the shelled assembly had to be sought whereby the layer of wax nearest the inner shell lining received rapid conducted heat sufficient to cause shock melting, thus leaving a space between pattern and shell. This rapid initial melting is necessary in order to avoid shell rupture due to expansion pressure as the pattern heats to its melting-point.



A—Burner.
B—Special refractories backed up with refractory and diatomite insulation bricks.
C—Steel casing.
D—Support grate.
E—Proportioning valve.

FIGURE 15.—*Schematic Outline of Pebble Heater.*

Although several methods are available for the above technique, the present production needs at Bristol-Siddeley Engines, Limited, are being met by means of heated fireclay grog of size $\frac{1}{4}$ in. to zero. A gas-fired plant designed and installed by Modern Furnaces, Limited, provides an output of 2,000 lb/h of grog at 300°C ±10°C.

The grog is taken to an overhead feed hopper by bucket-type elevator, and discharges with regular flow to an inclined rotary drum-type heater. The heater outlet delivers the heated grog to a small collector hood to which is fitted a distributor pipe system for the rapid distribution of the grog around the shell pattern, this being held in a special nimonic container and is positioned on a vibratory unit, thus ensuring quick and efficient packing of the hot grog into all pockets or voids of the shell. When correctly filled, the container moves to the next and firing stage. The heat input is provided by a single vortex burner, the combusted gases being in contra flow to the moving grog. A recording controller senses from a thermocouple fitted in the outlet collector hood. The entire plant is contained in an envelope of approximately 20 ft × 10 ft × 16 ft high.

Along with the various progressive steps aimed at higher productivity and consistency in the quality of the castings, it became obvious that the existing firing furnaces were in need of replacements, and, with the introduction of vacuum arc melting, additional furnace capacity was a first essential. During August, 1959, an order was placed with Industrial Furnaces, Limited, for the supply and erection, in the new vacuum arc melting section, of a bogie hearth furnace of the following overall dimensions : Length, 34 ft ; width, 11 ft, including trolley return track ; height, 12 ft, including recuperator.

This furnace is designed for continuous operation to heat cylindrical moulds of dimensions up to 9 in. diameter and 15 in. high to a temperature of 1,000°C. Each mould weighs approximately 40 lb, and the output on continuous working will be 10 moulds/h.

Conveyance trolleys have special refractory tops with side encasements of nimonic sheet steel and are propelled by a rack-and-pinion-type pusher. The trolleys are sand-sealed during their movement through the furnace. After reaching the side unloading door, which can be pneumatically or manually operated, the trolleys pass under a heat-retaining wall to a cooling chamber and then to the transfer bogie and return track for reloading. The furnace is loaded *via* an entrance vestibule where the doors are manually operated only.

Heating is provided by means of low level air/gas nozzle-mixing burners firing at an angle of 30° behind a box brick wall. The burners are connected in two zones, each having a motorized valve controlling linked air and gas flows and operating from indicator controlling instruments.

The furnace brickwork consists of 9 in. hot face insulation brick backed up by 9 in. of diatomaceous insulating bricks.

In April, 1959, this furnace was commissioned (see Figure 19), and a further similar installation was commenced in

June of that year and has now been in production for several months.

DOUGLAS LIMITED, KINGSWOOD

Among the many gas-fired installations that have been newly commissioned within the past year at the above firm, it is perhaps disappointing, from the point of view of this paper, that the majority of the plant is of conventional type. These installations include foundry ladle-heating equipment, annealing furnace, aluminium alloy solution and precipitation treatment ovens, low-temperature infra-red and forced-air continuous stoving and treatment ovens, alkaline degreasing machines, a cyclic annealing furnace and a radiant jet furnace. The last mentioned is, however, unconventional in design, and, despite the acknowledged use for many years of radiant-tube furnaces, this is considered worthy of mention here.

A radiant-tube furnace is virtually a muffle-type furnace, i.e., one in which the products of combustion do not enter the working space.

Conventional radiant tubes are of single-pass design, the burner firing into the tube at one end and the hot gases travelling along to exhaust at the opposite end. There is a tendency for hot spots to occur, and the efficiency is not high.

This radiant jet furnace, a product of the Incandescent Heat, Company, Limited, incorporates its " Jetube " radiant heating elements as shown in Figure 20. The combustion chamber adjoins the main tube circuit so that only products of combustion circulate within the tube. An air/fuel mixture is injected under pressure into this refractory-lined retractable combustion chamber, whence the products of combustion are ejected through a nozzle at high velocity. The kinetic energy of the emergent gases entrains the surrounding gases in the tube, imparting energy to them sufficient to cause the whole mass to recirculate. The mass flow is thus greatly increased by contrast with the conventional method, and this gives rise to high heat transfer rates, the recirculation being in the order of six or seven. Also, localized hot spots are completely eliminated.

FIGURE 16.—*Dipping, Stuccoing and Drying Primary Coating.*

The " Jetube " furnace is suitable for almost all commercial heat treatment operations. Figure 21 shows a general type that has been specially designed to make full use of the fabricated " Jetube ". The furnace chamber is lined with the latest low thermal capacity insulating materials, thus giving unusually rapid recovery rates.

Further economy is obtained by the use of special integral recuperators ; in a furnace operating at 1,000°C, the temperature of the exhaust is reduced to 500°C.

BRITISH RAILWAYS, SWINDON

When the railways were nationalized and British Railways (Western Region) took over the old Great Western Railway works at Swindon, it also took over the existing Great Western Railway gas works, which produced all the gas required for the railway locomotive works. A large proportion of the gas was used for heat treatment work in the production of railway rolling stock. In 1958, it was decided to close down the British Railways gas-making plant, and an agreement was reached for the South Western Gas Board to take over the supply of gas, which represented a load of approximately 1,700,000 therms/a.

At the same time, arrangements were made for a survey and performance tests to be carried out on the existing process equipment, as much of the existing plant required renewal or overhaul to bring the efficiency of working up to a higher level. A number of solid-fuel furnaces were in use, which could be converted to gas with advantage. As a result of this survey, it was decided to make recommendations for improved equipment, which would not only result in reduced fuel usage, but increase the output and reduce labour requirements in addition to improving working conditions. However, owing to the restrictions in the amount of capital available, not all the recommendations have been carried out as yet, but improvements are being made in stages.

A full account of this survey and the work carried out has been given in a paper by A. Riley, presented to the Western Junior Gas Association. One development of interest mentioned in this paper, is the introduction of a gas-fired furnace for bar heating for the manufacture of nuts. This work had been exclusively carried out by oil-fired furnaces. When a nut-forging machine was being installed, the opportunity was taken to introduce a prototype gas-fired furnace, designed in the Gas Board's Area Industrial Office, for heating the bar. This furnace, which operates at a temperature of about 1,250° to 1,480°C, was designed to incorporate recuperation on the air supply and was built by Industrial Furnaces, Limited, Kingswinford, Staffs., and installed for trial. (See Figure 22.)

The results obtained fully justified the claims that the work can be carried out by gas as economically as by oil and with improved results. As a result of the test carried out on this furnace, it was found that, with the present method of working (i.e., heating individual bars and manually feeding to the nut-forging machine), only about 10 per cent of the strokes are effective in producing nuts, due to the loss of feed during the transference of bar from the furnace and back.

A design has been prepared for a continuous bar-heating furnace, which will feed directly into the machine, thus allowing more strokes to be effective and considerably reducing the labour and time required in the production. Up to the moment, no steps have been taken to build a prototype, as

FIGURE 17.—*Mould-firing Oven and Method of Mould Removal.*

consideration has to be given to the effect on the general production line in the works.

WESTINGHOUSE BRAKE AND SIGNAL COMPANY LIMITED, CHIPPENHAM

This well-known engineering organization has used gas as a fuel for a number of its processes for many years. In the foundry, its core-drying and mould stoves are gas-fired, but in the smithy oil-fired slot furnaces are used for billet heating prior to forging. The type of furnace in use is not particularly well designed, there is considerable wastage of heat through the feed slot, and the working conditions are bad. As results on the bar furnace installed at British Railways, Swindon, had proved that a gas-fired furnace could give improved working, it was suggested to Westinghouse that a slight modification of this furnace would improve its output and working conditions in the smithy.

To demonstrate this point, a working test was carried out on the oil-fired furnace (see p. 146), which showed that the cost per thousand pounds of metal heated was 432·3*d*. A gas-fired furnace similar to that installed at British Railways was installed and a further test carried out (see p. 147) In this case, the cost per thousand pounds of metal was only 328·6*d*. and over a year this represents a saving of approximately £200. The furnace was designed by the Board's Area Industrial Office and was constructed by Industrial Furnaces, Limited, Kingswinford, Staffs., the main features being the employment of recuperation, efficient insulation and reduction of the size of the slot to accommodate more closely the dimensions of the billets, thus reducing direct radiation losses. By lowering the height of the slot from floor level, the handling of billets by the operatives was made much easier, and the general reduction of heat losses resulted in improved working conditions.

The general appearance of the furnace is shown in Figure 22*a*. The furnace case is of 0·3 in. mild steel plate braced with R.S. sections, the inner lining is of 4½ in. firebrick, backed with 3 in. of high-temperature insulation and 4½ in. of normal diatomaceous insulation. High-temperature Morgan castable refractory has been used to line the hearth on a 4½ in. layer of firebrick backed with insulating material.

Firing is by one Industrial Furnaces, Limited, type 2000 medium-pressure gas burner fitted in a side wall and directed under the semi-elliptical arch. Products of combustion are distributed evenly around the heating chamber and then pass through the working slot to the recuperator sited over the opening. The recuperator consists of a bank of ¾ in. i.d. tubes, the lower three rows of tubes being of stainless steel and the remainder in chrome steel.

With this arrangement, working temperatures in excess of 1,400°C are attainable.

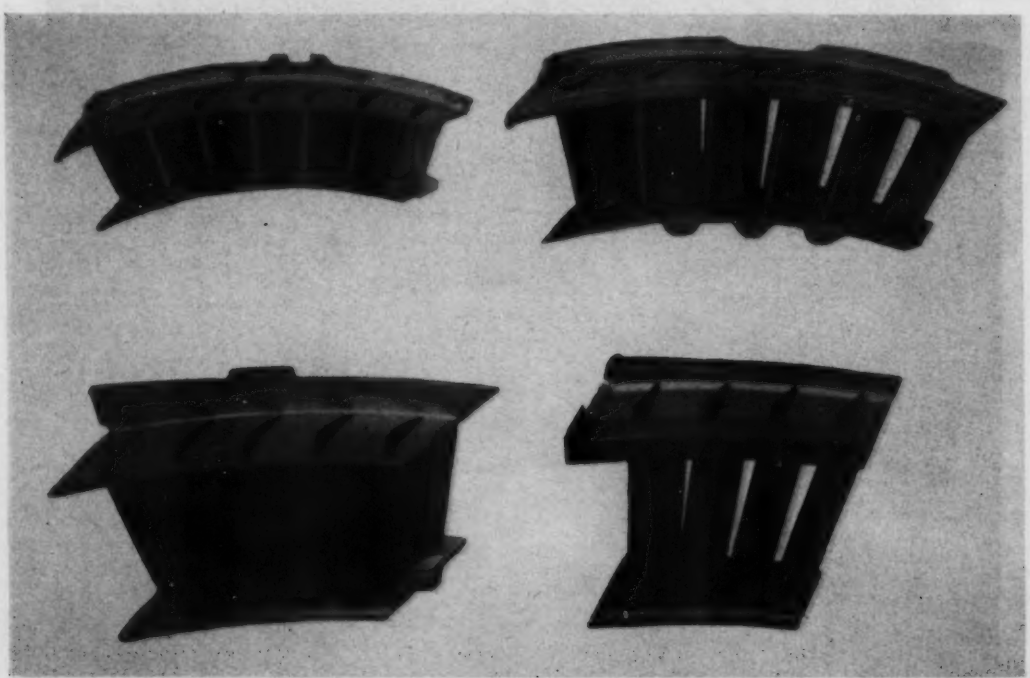
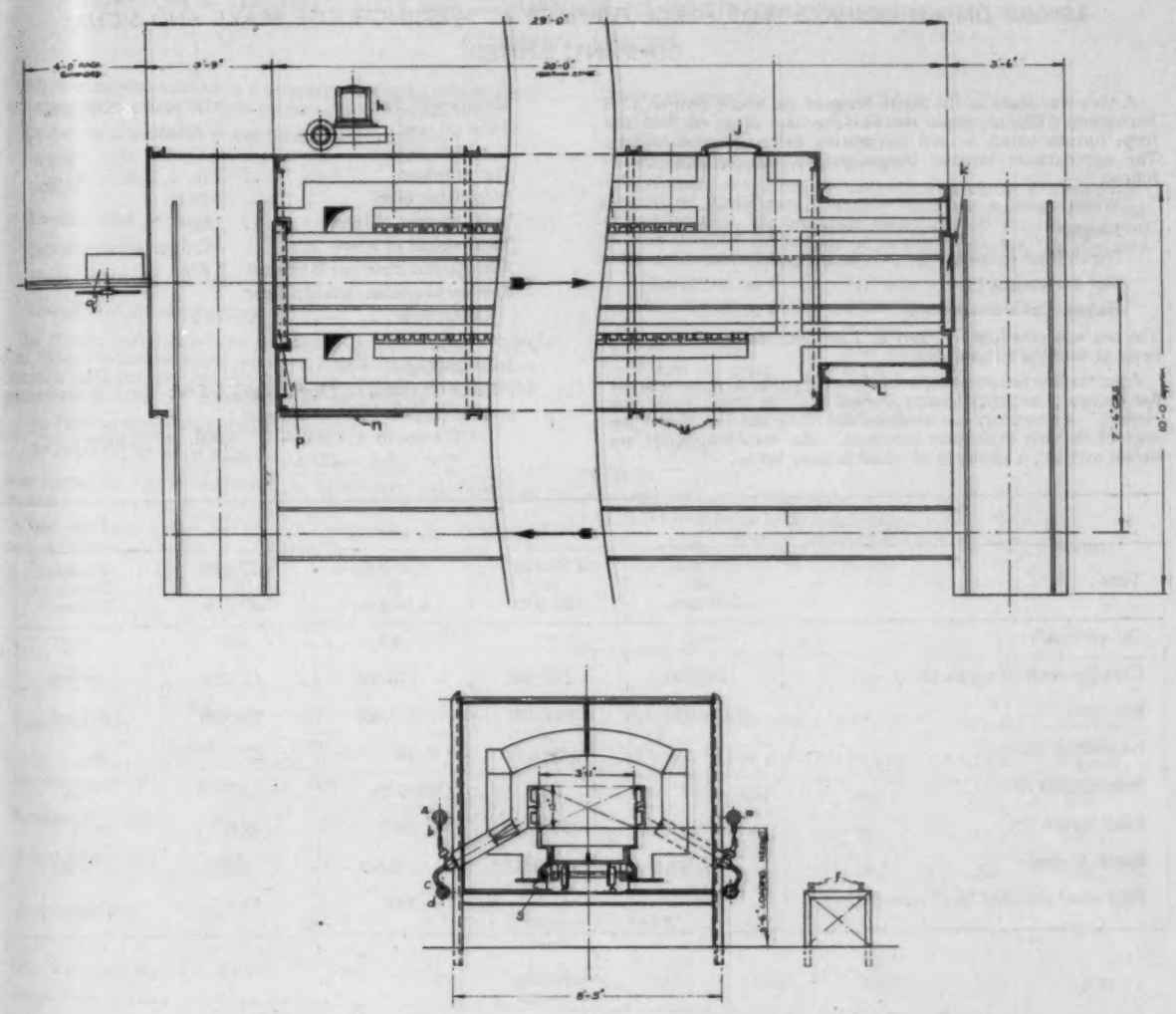


FIGURE 18.—*Stator Segments (Hollow Blades).*



a—Air manifold.
b—Air control valve.
c—Gas control valve.
d—Gas manifold.
e—18 nine-per-side medium-pressure forced-draught burners ; front four-per-side arranged on independent gas/air supply lines with separate by-pass control.
f—Return tracks.
g—Sand seal.
h—Blower fan supplying air to burners *via* the recuperator ; position of fan to suit suite.
j—Charge unloading door (pneumatic).
k—Pneumatically operated truck-unloading door.
L—Mild steel fabricated casing.
M—Position of burners.
n—Vestibule entrance fitted with sliding door.
P—Pneumatically operated door between vestibule and heating zone.

FIGURE 19.—*Continuous Mould-heating Stove.*

REPORT ON AN OIL-FIRED SLOT FORGE FURNACE AT WESTINGHOUSE BRAKE AND SIGNAL COMPANY, LIMITED

A visit was made to the Smith Shop of the above firm on 17th November, 1959, to obtain the working data of an oil-fired slot forge furnace which is used for heating billets prior to forging. The approximate internal dimensions of this furnace are as follows :—

Width	3 ft 0 in.
Height	1 ft 6 in.
Depth front to back	1 ft 8 in.
Slot dimensions	3 in. × 2 ft 6 in.
Height of slot above floor	3 ft.

The test was scheduled to start at 7.30 a.m., the furnace already being at working temperature.

After the first few minutes, it was found that the oil meter was not functioning ; an investigation showed that the meter rotor was broken. A new meter was obtained and fitted, but this delayed the start of the test until after luncheon. The results obtained are shown overleaf, a summary of which is given below.

Duration of Test	1.05 p.m. to 5.07 p.m.
Total oil used	21·0 (gal)
Total Btu input	3·57 mill.
Size of billets	2 in. × 2 in. × 3½ in.
Weight per billet	3·28 lb.
Total number of billets	141
Total weight of billets	462·5 lb.
Average Btu input per lb of steel	7,719
Average equivalent gas input per lb of steel	16·4 ft³

Cost :

Price of oil/gal : 9·5*d.*

Price of oil/therm (1·7 therms/gal) : 5·6*d.*

Cost to process 1,000 lb of metal :

7,719 Btu/lb × 1,000 = 7,719,000 ≡77·2 therms

∴77·2 × 5·6 = 432·3*d.*

1	2	3	4	5	6
Time	1.05 p.m. to 2.05 p.m.	2.05 p.m. to 3.02 p.m.	3.22 p.m. to 4.14 p.m.	4.22 p.m. to 5.07 p.m.	Average Hourly Figures
Oil used (gal)	6·4	5·5	4·9	4·2	5·95
Calorific value of oil/gal (Btu)	170,000	170,000	170,000	170,000	170,000
Btu input	1,088,000	935,000	833,000	714,000	1,011,500
Number of billets	43	41	30	27	40
Weight/billet (lb)	3·28	3·28	3·28	3·28	3·28
Total weight (lb)	141·0	134·5	98·4	88·6	131·0
Btu/lb of steel	7,716	6,951	8,465	8,058	7,721
Equivalent gas input/lb of steel (ft³/lb)	16·4	14·8	18·0	17·1	16·4

REPORT ON A GAS-FIRED SLOT FORGE FURNACE AT WESTINGHOUSE BRAKE AND SIGNAL COMPANY, LIMITED

This furnace was installed as a prototype following tests made in November, 1959, on an oil-fired furnace doing a similar duty.

The internal dimensions of the furnace are as follows :—

Width	2 ft
Height	1 ft
Depth : back to front	1 ft
Slot dimension	3 in. × 2 ft
Height of slot above floor	2 ft 7 in.
Design working temperature	1,300°C

The furnace was initially lit for drying-out on Tuesday, 27th June, 1960. In the following two days, trouble was experienced in obtaining sufficient gas flow to bring the furnace to a working temperature of 1,300°C. The cause was traced to be :—

(*a*) Packing material in non-return valve.

(*b*) Incorrect air jet in burner.

After correcting the above items, a satisfactory gas flow was obtained.

A test was carried out on 5th July, 1960, and the following results obtained :—

Heating up period :

Time	7.47 a.m. to 8.27 a.m. (40 min.)
Gas consumed	450 ft³
Furnace temperature	1,250°C

The furnace could not be used immediately as a breakdown occurred on the Massey hammer. This was repaired and work commenced after the breakfast break, at 9.07 a.m. Production has been divided into periods of 1h where possible. A summary of the test results is given below.

Duration of test	9.07 a.m. to 4.12 p.m.
Total gas used	4,480 ft³ (not including luncheon break)
Size of billets	2 in. diameter × 4½ in. long
Weight per billet	4·2 lb
Total number of billets	236
Total weight of billets	991·2 lb
Average input of gas (ft³/lb)	4·52

Cost :

Price of gas : 15·5*d*/therm.

Cost to process 1,000 lb of metal

$4{\cdot}52 \times 1{,}000 \times 470 = 2{,}124{,}400$ Btu $\equiv 21{\cdot}2$ therms

$21{\cdot}2 \times 15{\cdot}5 = 328{\cdot}6d.$

1	2	3	4	5	6	7	8	9	10
Time	9.07 a.m. to 10.07 a.m.	10.07 a.m. to 11.07 a.m.	11.07 a.m. to 11.30 a.m.	11.30 a.m. to 1.07 p.m.	1.07 p.m. to 2.07 p.m.	2.07 p.m. to 2.56 p.m.	2.56 p.m. to 3.56 p.m.	3.56 p.m. to 4.12 p.m.	Average Hourly Figures
Gas consumed (ft³)	830	920	280	580	840	680	760	170	820
Number of billets	32	57	16		39	44	32	16	43
Weight/billet (lb)	4·2	4·2	4·2	Luncheon break	4·2	4·2	4·2	4·2	4·2
Total weight (lb)	134·4	239·4	67·2	Luncheon break	163·8	184·8	134·4	67·2	180·6
Gas input (ft³/lb)	6·17	3·84	4·17	Luncheon break	5·12	3·68	5·67	2·53	4·54

SAVING IN COST BY USE OF GAS

Taking the cost with oil firing to process 1,000 lb of steel as 432·3*d.* as shown in the comparative oil-firing report :

$432{\cdot}3 - 328{\cdot}6 \equiv 103{\cdot}7d.$/1,000 lb. of metal.

Assuming an output of 2,000 lb/24 h day and 250 working d/a,

Annual Saving $= 103{\cdot}7 \times 2 \times 250 = 51{,}850 \equiv$ £216 0s. 10*d.*

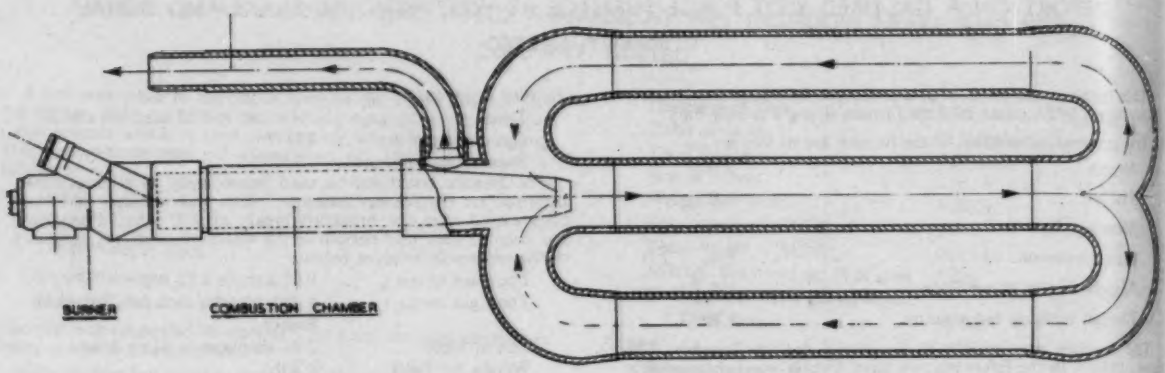


FIGURE 20.—*Diagram of Radiant Jet Furnace incorporating " Jetube ".*

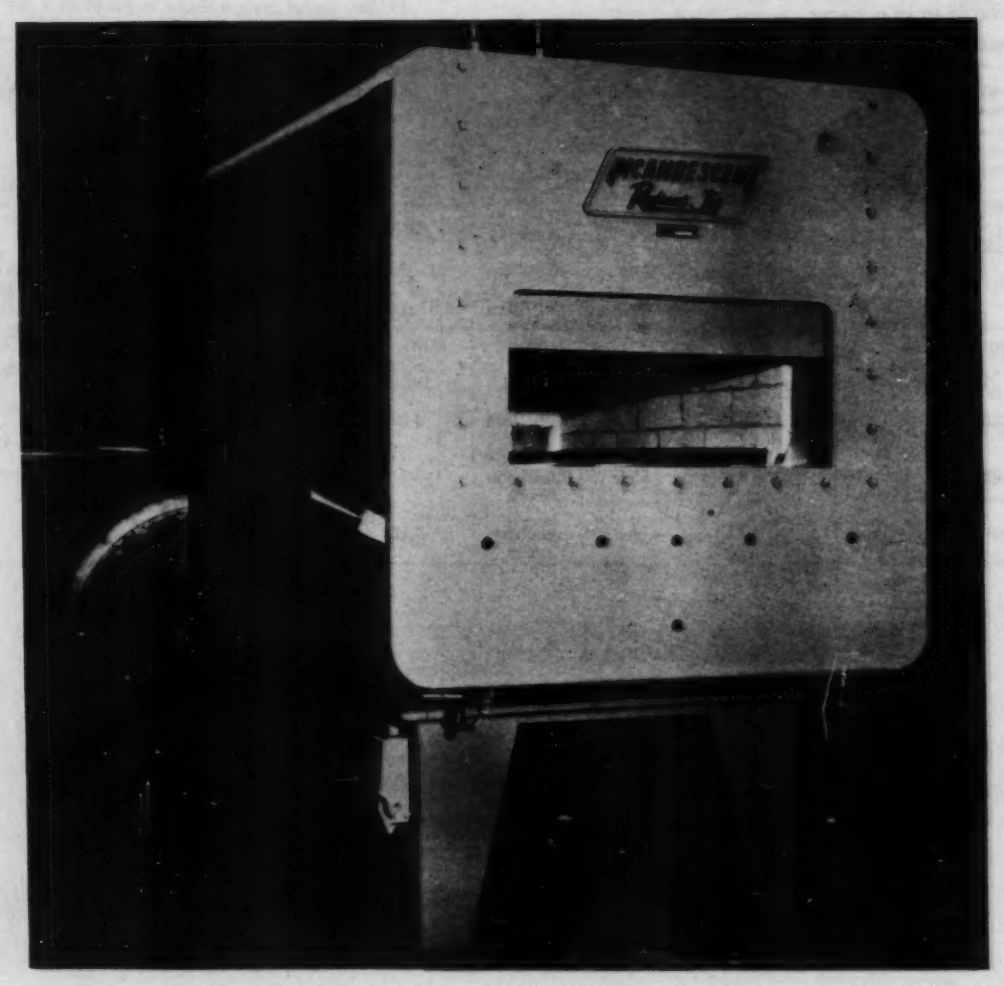


FIGURE 21.—*A General Type of " Jetube " Furnace.*

J. W. SINGER AND SONS, LIMITED, FROME

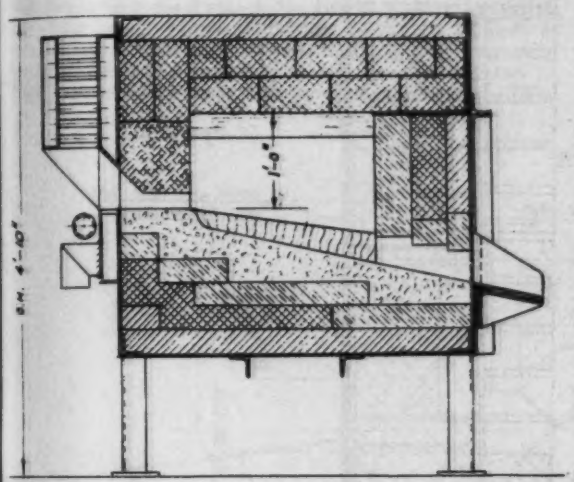
This old-established firm of brass founders, which has examples of its work displayed all over the world, has used gas extensively for many years, but, with increasing costs of gas, it was considering alternative fuels for heating brass billets. The existing gas-fired furnaces were heated by natural-draught burners, and the billets, which ranged from about ¼ in. diameter × 1 in. long to 1 in. diameter × 2 in. long, were fed into the furnace manually.

The furnaces used for heating these small billets are rectangular chambers with a feed chute at the back and an open front for removal of the heated billets. Firing is by means of a fish-tail burner using premix gas and air, firing downward and inwards across the slot ; heat losses are high and wastage considerable, as there is no control over the time the billets are in the furnace, this being dependent upon the operator, who has to pick each billet from a number presented at the opening.

It was suggested that an improved furnace would cut both fuel costs and wastage of billets due to too long soaking in the heating zone, and eventually the design was prepared as shown in Figures 23 and 23*a* for a furnace that would give a steady feed of billets at the predetermined temperature. A prototype is in course of construction and will be installed shortly.

The feedstock is introduced into the top of the furnace, which comprises an outer combustion space containing a perforated circular iron retort divided into nine chambers by haematic iron shelves. Each shelf has a segmented hole to allow passage from chamber to chamber ; the holes are positioned helically so that, as the billet drops through the retort, it must first travel around each chamber. This travel is produced by a central shaft that carries a distribution wheel in each chamber. On rotation, the spokes of the wheel push each billet around until it falls into the next lower chamber. This gives a full travel through the furnace and feeds the billets, one at a time, to the outlet. A foot-operated control enables the operator to regulate the rate of feed to suit his requirements.

The furnace is heated by two 1 in. " Selas " premix burners firing tangentially round the retort at the bottom, and flued from the top. In this way, the billets pass downward into the highest temperature at the point of exit and remain at working temperature for the minimum length of time, thus reducing wastage due to overheating.



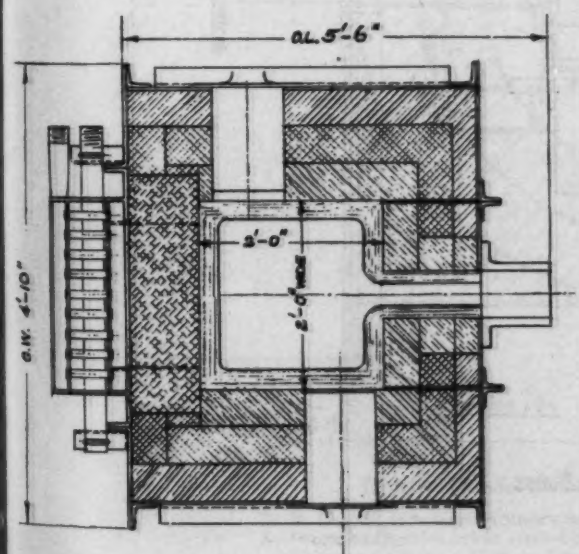


FIGURE 22.—*Gas-fired Recuperative Slot-Forge Furnace.*

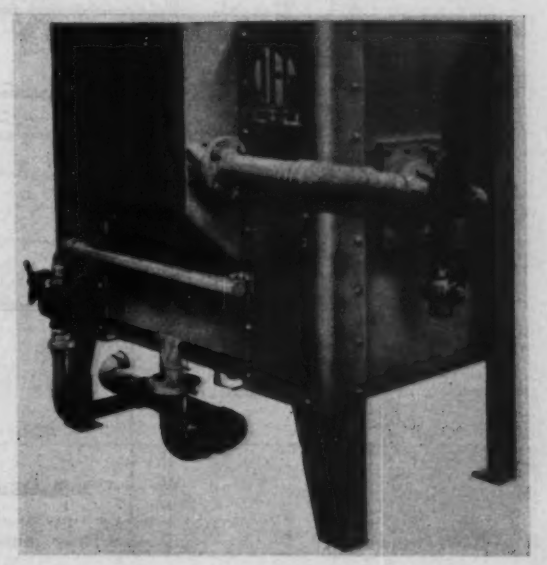


FIGURE 22*a*

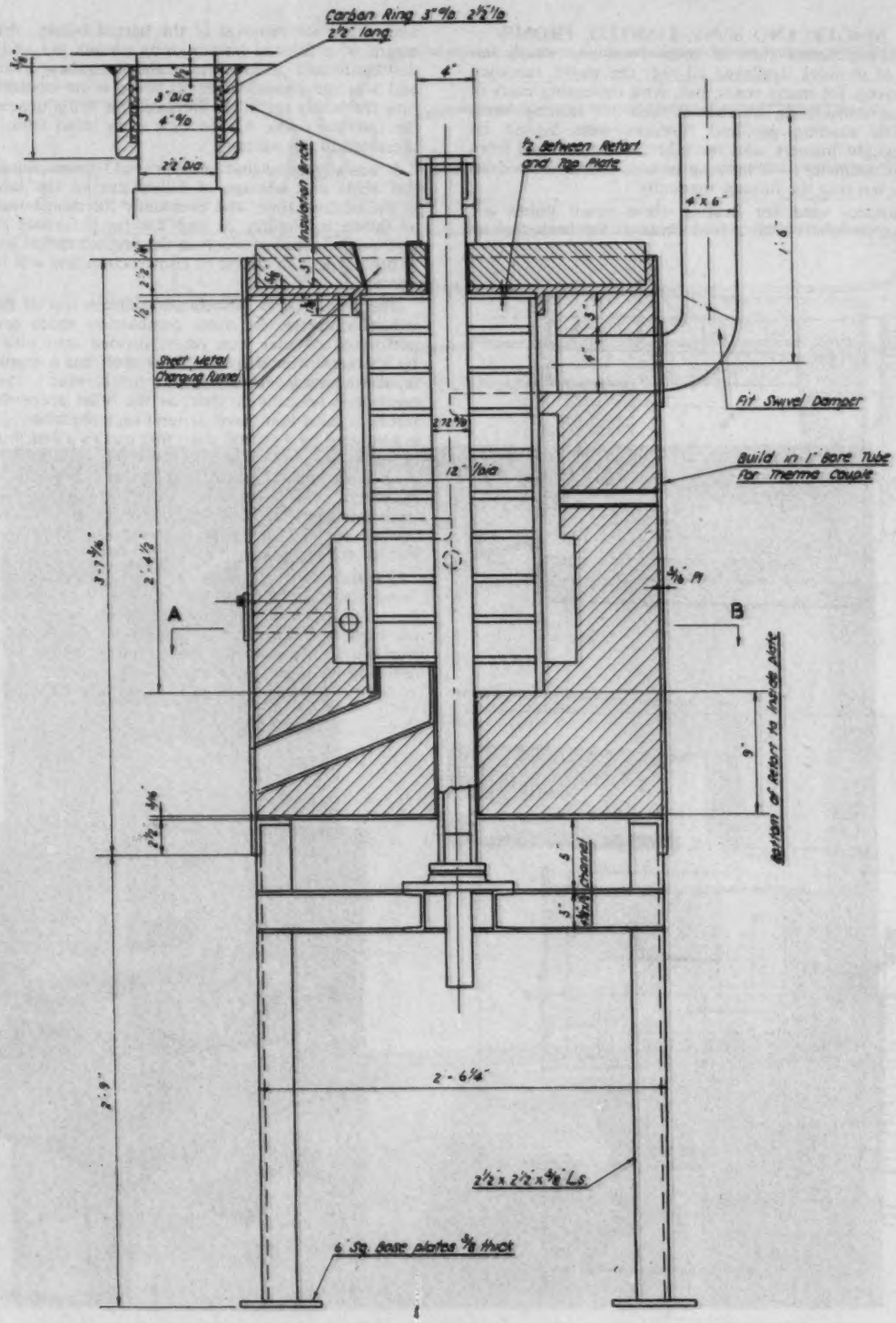


FIGURE 23.—*Design for an Improved Gas-fired Furnace for the Heating of Brass Billets.*

IV CONCLUSION

In the preparation of this paper, only a selection of more recent developments has been covered and no mention is made of the increased load obtained due to installation of standard types of equipment, which could legitimately be included under the description of "Development", as the main intention is to emphasize the necessity for special equipment for specialized processes. In many instances, the need for this type of equipment and the fact that the gas industry can provide it, is not appreciated by industrial manufacturers.

The long history of the gas industry as a supplier of refined fuel should be a good reason for assuming an accumulated knowledge of the problems involved in the use of such a fuel, but the fact that gas has been available for a long time can give rise to the impression that it is out of date and is being superseded by newer and more publicised fuels. That this is not so must be demonstrated by continuing development of new techniques and equipment.

It is not always easy to persuade someone used to the conventional idea of a furnace that it may be possible to do away with the mass of brickwork and get better results by other methods, and instances are known where even demonstration has not carried conviction.

Too often, standard oven furnaces are being used for work other than that for which the furnace was designed, but, because the results required can be achieved, no thought is given to alternative methods until it is too late and one of the more glamorized fuels has stepped in.

To illustrate that it is possible to prevent this happening is one of the purposes of this paper, and the Authors hope that the examples quoted emphasize that it is necessary to be constantly alert to new developments and to be able to make the first approach with a new technique.

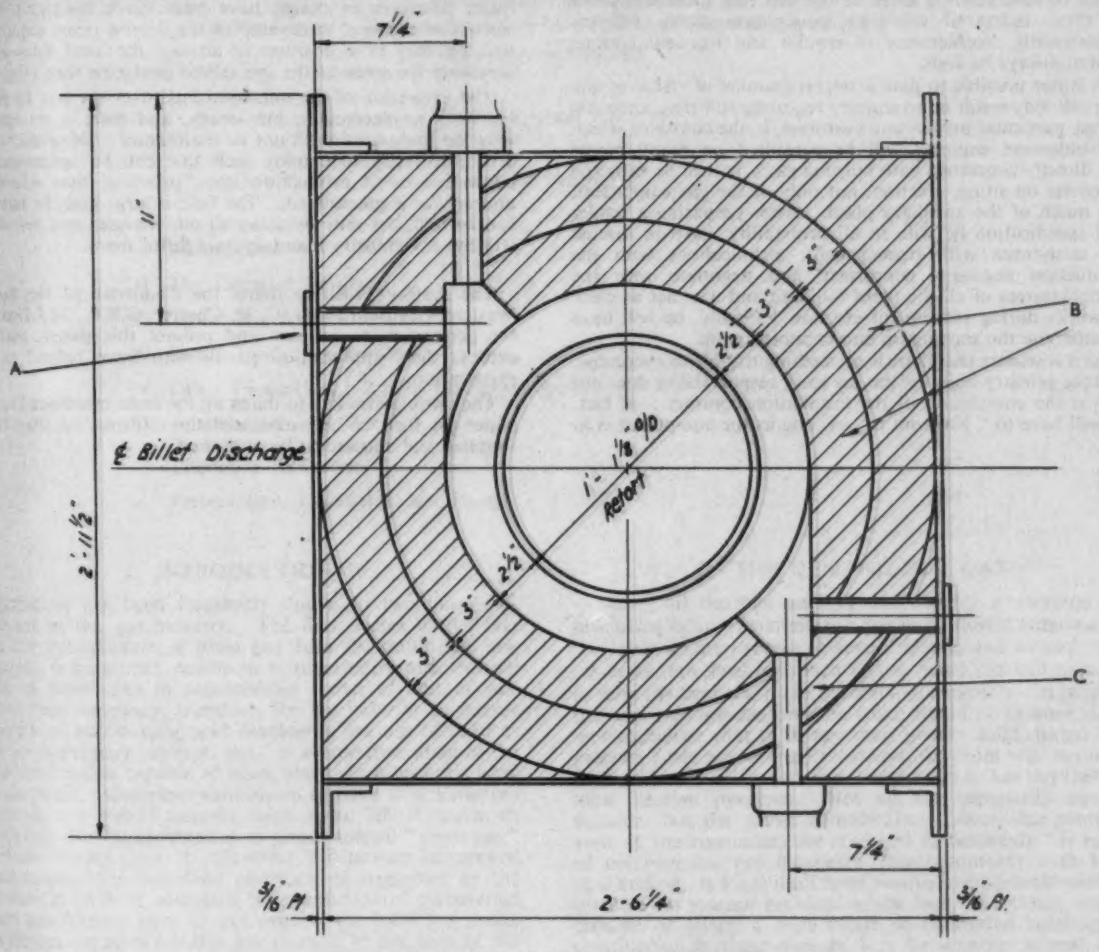


FIGURE 23*a*.—*Section on Line A—B of Figure* 23.

A—Build 1½ in. tube into brickwork for lighting-hole. Fit swivel cover.
B—Fit two rings circle bricks around combustion chamber :—
Outer one : 9 in. × 7¼ in. × 3 in. × 3 in.
Inner one : 9 in. × 6¾ in. × 3 in. × 3 in.
C—Fit two Selas Mixture Burners No. 119/3 nozzles. 1 in. bore ; 6 in. long.

There must be many processes, now being carried out by alternative fuels, that could have been retained or obtained for gas if suitable " tailor-made " equipment had been presented early enough.

Modern business organization makes it difficult to maintain contact with all the people who have some say in ultimate decisions as to which fuel shall be used, and very often the persons most involved in the use of the equipment have little responsibility in its choice. Equally, top-level management in the larger organization does not interest itself in technicalities, but relies on the advice of its specialists.

Only contact at all these levels can result in sufficient pre-knowledge of projects being obtained, to enable new ideas to be considered and tried before decisions are reached.

There are, approx., 3,000 industrial consumers in the South West Area, which gives an average distribution of 200 consumers to each engineer or representative. This may not seem a large number to be visited by one individual, but, when consideration is given to the fact that quite a number of these industrial concerns incorporate many different departments, maintenance of regular and frequent contact cannot always be kept.

It is not possible to plan a set programme of visits, as any one call may result in an enquiry requiring full-time attention to one particular project and customer, in the course of which the industrial engineer will be consulted on many points not directly concerned with burning gas ; he will be expected to advise on siting, erection, not only of the gas equipment, but much of the ancilliary plant. After preparing a tender and specification he will, in all probability, have to discuss the economics with management, technicalities with the production engineers concerned, and negotiate with the manufacturers of all the plant required and also act as clerk of works during subsequent erection. Finally, he will have to supervise the starting-up and commissioning.

As it is seldom that there is no teething trouble to overcome, and the primary object is the gas load, responsibility does not end at the completion of the installation contract ; in fact, he will have to " live with it " as long as the equipment is in use.

Primarily, the industrial engineer's working time and experience should be at the disposal of the consumer, however the time available for consumer contact in the search for new business is limited by carrying out the foregoing requirements. The success achieved by the gas industry's various Industrial Departments is contingent upon the measure of co-operation received from the Mains and Services and Fitting Departments, the stores and clerical staffs who facilitate the necessary " paper work ".

New methods do not arrive out of the blue, but are usually the result of assessing and rejecting various suggestions until a final solution is attained. To this end, it is essential that industrial engineers, who are very often working on their own, should have frequent opportunities for meeting their colleagues in " open forum ", where any problems and ideas can be discussed.

Full co-operation with furnace manufacturers must be maintained in the production of new equipment, for, although many advances in design have been made by them, they cannot be expected to develop all the diverse plant required ; nor are they in a position to acquire the local knowledge necessary for some of the specialized problems that arise.

The expansion of the industrial load over the last 10 years has been unspectacular, but steady, and there is no reason why the increase should not be maintained. Manufacturers are more ready to employ fuels that can be automatically controlled to fit production lines, provided that reliability and service is guaranteed. The field is large and the harvest can be rich, but only by using all our energies and resources will the gas industry maintain its rightful share.

The Authors wish to thank the Chairman of the South Western Gas Board (Mr. C. H. Chester, C.B.E., M.I.Gas E.) for permission to prepare and present this paper, and to express their appreciation to all who have helped in its preparation.

They would also like to thank all the firms mentioned in the paper for their co-operation and the information they have supplied and allowed to be published.

SOME CONSIDERATIONS OF GAS MAKING IN TERMS OF THE NATIONAL FUEL SITUATION FOR THE NEXT 25 YEARS

By M. W. THRING, M.A., F.Inst.P., F.Inst.F., M.I.Chem.E.
(*Professor of Fuel Technology and Chemical Engineering*)
and
C. HULSE, B.Sc.(Birm.), Ph.D.
(*Senior Lecturer, Department of Fuel Technology and Chemical Engineering*)
University of Sheffield

COMMUNICATION No. 581

TABLE OF CONTENTS

		PAGE
I	Introduction	493
II	The Demand for Gas	493
III	Town Gas Sources of the Future	494
IV	Total Gasification of Coal	495
V	Other Possibilities : Future Developments	496
VI	Conclusions	497
	Literature References	497
	Presentation, Discussion and Reply	497

I INTRODUCTION

Attention has been frequently drawn to two anomalies inherent in the gas industry. The first relates to the fact that the manufacture of town gas from the traditional raw material, coking coal, results in a quantitative and thermal yield of solid coke in considerable excess of that of gas. It has been necessary, therefore, for the industry to pursue a policy of encouraging and developing the use of coke as well as its primary product, gas. It is true that some of the coke produced is capable of being absorbed in meeting peak gas demands. Complete gasification of coke in a water gas plant yields a gas of calorific value about 300 B.t.u./cu. ft, which can then be carburetted to give a normal " town gas " of about 500 B.t.u./cu. ft. However, this process has proved uneconomical for base-load purposes, as suggested by the fact that in 1958-59, although the production of carburetted water gas formed only 17 per cent of the total gas make, production capacity for this gas formed 35 per cent of the total capacity.[1]

The other anomaly is that the gas industry obtains both its possible raw materials, coal and oil, from its competitors. This situation, inescapable as far as the gas industry is concerned, is one that could not normally persist in industry generally.

II THE DEMAND FOR GAS

Nearly all the fuel used in this country is required for producing heat. Even electric power is mostly obtained *via* the intermediate process of steam raising, and in such processes as iron smelting much of the " fuel " is still required to raise the temperature of the reacting materials. In general, the user may choose between solid, liquid or gaseous fuels, or electricity : that is to say that, just as solid, liquid and gaseous fuels are mutually convertible, from the technical point of view, so it is possible, technically, to use any fuel for most heating purposes. Not all are necessarily equally suitable, but the prime considerations, from the point of view of the consumer, are cost and convenience. In terms of convenience, gas compares very favourably with both coal and oil. It lends itself most readily to automatic control, involves no storage problem to the user, it is clean, and is capable of giving a wide range of controlled combustion conditions. In these respects, it is far superior to coal, and generally, it is fair to say, to oil also. Unfortunately, when cost is brought into the picture the story is quite the reverse. Although it is difficult to assess exactly relative costs, since, among other things, they vary considerably in different parts of the country, it is apparent that everywhere coal is cheapest and gas more expensive than oil.

It seems certain that, if this country is to improve progressively its standard of living, then its overall heating requirements will increase, despite the tendency of improvements in process efficiency to offset this. Nevertheless, in recent years the sales of gas have been relatively stationary. Moreover, it has been found increasingly difficult to sell economically the coke produced. It is not surprising, therefore, that the industry is becoming increasingly aware of the absolute necessity of discovering means of making cheaper gas, without, at the same time, producing more coke. In the opinion of The Gas Council[1], it is imperative that the total cost of gas should not exceed 10*d.*/therm inclusive of capital charges.

In the authors' opinion, factors other than relative costs also mitigate against town gas compared with its chief competitor, oil. With regard to the first, nothing can be done. It is that the oil industry is inherently more flexible in its capacity to vary the proportions of its saleable products. The proportions of gas, coke and by-products made by the gas industry are more or less fixed independently of relative demands, whereas the oil industry can with comparative ease switch production between light and heavy fractions. Indeed, the whole of the past history of the latter has been one of continual change of emphasis in the relative importance of its products. This inflexibility on the part of the gas industry serves to emphasize the importance of bringing down the price of gas if it is to succeed in keeping its place with respect to its competitors.

Another factor which was important in the past, although, happily, this is diminishing, particularly in the domestic field, was the apparent reluctance on the part of the gas industry to seek vigorously new outlets for its main product, by carrying out, on a sufficiently large scale, development work at the consumer end of its organization. It could be argued that, since nationalization, one of the duties of the industry is to extend the sales of gas, in order to be in a position to reduce its price to existing customers. Technical and economic development in gas production will avail little if insufficient energy is deployed in development of its application. In the authors' view, this aspect of the problem is one that should be shared between producer and consumer.

III TOWN GAS SOURCES OF THE FUTURE

It is apparent from the foregoing that, if the gas industry is to continue to play its part in this country, its traditional methods will no longer serve. Conventional carbonization techniques are probably incapable of much further improvement, but will survive for some time and continue to supply whatever demand exists for " gas works " coke. The Clean Air Act might have been supposed to lead to a rapid increase in demand for coke. In the event, it would seem that both coal-derived smokeless domestic fuel, other than coke, as well as oil, are frequently preferred. Unless techniques for improving reactivity are forthcoming, it seems unlikely that the demand for domestic coke will appreciate. This situation need cause no alarm provided that cheap total-gasification techniques become available. Gas is even more suitable, technically, than coke for domestic heating, since, apart from its controllability, it does not give rise to the emission of sulphur dioxide with the chimney gases. It is unfortunate in many respects that the Clean Air Act did not extend to the prohibition of noxious gases as well as smoke.

While the need for metallurgical coke continues, some coke oven gas will continue to be available for distribution as town gas in certain areas. The quantity available could with advantage be increased. This is in fact being done in the Sheffield area where, at Manvers Main coke ovens, the National Coal Board is installing an experimental Ruhrgas producer, with the object of releasing the coke oven gas at present used for heating the ovens. The Ruhrgas process gasifies any type of pulverized coal with preheated air in a shaft-type reactor, 100 ft high by 10 ft in diameter, mounted on a cyclone chamber. The reaction takes place at about 1,500°C, and the ash is run off as a molten slag. The gas has a calorific value of 90 to 100 B.t.u./cu. ft, and it is thought that the coke oven gas released by its use might sell at 7*d.* to 8*d.*/therm.

In addition to these supplies of town gas, other relatively minor sources will continue to be developed. These include methane drainage from coal mines, the exploitation of indigenous natural gas resources, such as that of the Coulsland anticline in Midlothian, the use of oil refinery tail gases, light distillates, *etc.*, and the importation of refrigerated natural and refinery gases.

A possibility that cannot be ruled out is the piping of natural gas from North Africa. In considering new processes for future bulk supplies of gas, a factor that needs to be borne in mind is the desirability of the gas being similar (especially with respect to calorific value and density) to that produced by conventional means. However, if it could be shown that a leaner or denser gas could be produced very cheaply, the industry should be prepared to face the prospect of changing jet sizes on existing appliances (estimated at £10/consumer). The basic criterion should be whether prospective savings in cost of gas manufacture would offset the interest on the capital charges involved.

It would seem that the greatest promise for the bulk of future gas supplies lies in the total gasification of either petroleum oil, or coal, or both. Both possibilities have been under investigation by The Gas Council for some years and a number of catalytic processes, notably the Segas and Onia Gegi, already make a noteworthy contribution to the total gas make of the country.

The object of total gasification may be regarded as the enhancement of the ratio of hydrogen to carbon as found in the raw material. Thus, the available hydrogen (neglecting that bound to oxygen, nitrogen and sulphur) to carbon ratio for a number of substances are as follows[1] :—

	Hydrogen to Carbon Ratio by Weight
Average bituminous coal ..	4·5
Heavy fuel oil	13·5
Diesel oil	14·8
Butane	21·0
Propane	22·4
Town gas	32·4

Although it does not necessarily follow, the above figures would suggest that it should be easier to convert from an oil to the hydrogen to carbon ratio of town gas than from coal. In fact, such is the case : the process is at present more highly developed for the use of oil.

Hydrocarbon oils may be partially converted to permanent gases by simple thermal cracking, but much of the feed is lost in the simultaneous make of heavy tarry matter and carbon. The introduction of steam with the oil feed and the use of a suitable catalyst, such as nickel (Onia Gegi process) reduce or eliminate carbon deposition and increase the gas yield. A cyclic process is employed, since the steam/carbon reaction is endothermic, and it is necessary for the catalyst bed to be periodically reheated by, for example, the combustion of methane. Where some carbon is deposited in the catalyst bed, its combustion during the reheat period contributes to the heating of the catalyst. Heat recovery from

the make gas is practised by preheating the combustion air used during reheat in a regenerative system.

Plant for the gasification of oil should logically be sited near the refinery. This is being done, for example, in the case of the new Romford works of the North Thames Gas Board, which will take tail gases from the Shellhaven refinery, and also on the Isle of Grain site (South Eastern Gas Board) where it is planned to use a variety of feedstocks, dependent on supply.

IV TOTAL GASIFICATION OF COAL

Although the total gasification of coal has been carried on for many years, using an air/steam blast, this gas is generally considered unsuitable for use as town gas. Its calorific value is only about 165 to 180 B.t.u./cu. ft, and it has a high carbon monoxide content and density. The use of an oxygen/steam blast, however, as in the Lurgi process, increases the calorific value to about 400 B.t.u./cu. ft, which figure is, however, still too low for many areas. Accordingly, the gas may require enrichment by the use of a suitable petroleum stock such as butane. The Lurgi process is the only one that, at the moment, has reached the commercial scale for the complete gasification of coal to produce town gas. A plant at Westfield, in Scotland, is due to be commissioned in late 1960, and it is hoped that a second plant at Coleshill will be commissioned about 1963.

The process incorporates a conventional rotary-grate producer, but works under pressures up to 25 to 30 atmospheres (440 lb/sq. in.) with a mixture of pure oxygen and superheated steam. The coal is introduced through the coal lock chamber at the top of the generator. The gasifying agent, consisting of steam and oxygen, flows upwards and gasifies the fuel. Ash is removed through the lock chamber for ash at the bottom of the generator. The crude gas leaving the generator is washed and pre-cooled in a spray cooler.

The gas is further cooled under pressure in tubular coolers whereby, apart from steam, the by-products tar and oil are condensed and recovered. The benzene in the gas is removed in an oil washing tower and recovered by distilling the absorbing oil. The carbon dioxide in the gas is washed out with water under pressure. A high-pressure pump supplies the water to the washing tower where it takes up the carbon dioxide. It then expands in a turbine, releasing carbon dioxide and a small fraction of combustible gases. Part of the power consumption of the pump is recovered in the turbine. Simultaneously, most of the hydrogen sulphide is removed from the gas in the water wash. The water is aerated in an aeration tower and returns to the washing tower *via* the high-pressure pump. The gas released from the expanding water together with the gas from the coal lock chamber is used for superheating the steam required for gasification.

The gas leaving the water wash is freed from traces of hydrogen sulphide by passing it through iron oxide in a dry purification plant.

Until recently, a limitation on fuels and, consequently, calorific value, was the inability to control the passage of gases through the fuel bed when using caking coals. However, an arrangement of rotary stirrers, which prevents agglutination and continuously maintains the fuel bed in granular form, has been developed recently. In sustained experiments over two and a half years, the Lurgi Company established that fuels of almost every character can be efficiently gasified, and, apart from a minimum size of $\frac{1}{4}$ in., the use of these coals was limited only by their caking power. Now, due to the new stirring device, coals with agglutinating power equivalent to a B.S. swelling index of 10 can be handled by the plant.

It is also claimed that considerable progress has been made in raising the output of the producer units. In earlier plants, the output of a unit with a diameter of 8 ft gave normal output of 180,000 to 250,000 cu. ft of crude gas/hr at s.t.p. New measures to ensure uniform fuel distribution, which also enables the refractory lining to be dispensed with, have raised the outputs of 350,000 cu. ft with typical coals to 420,000 cu. ft/hr of crude gas. Larger producers have also been developed with a diameter of 12 ft and with an hourly gas make of 700,000 to 800,000 cu. ft.

The Westfield plant in Fifeshire will be the first of its kind in Britain to employ the Lurgi process to make gas at high pressure from coal that is too small and too dirty to carbonize by conventional means. Construction began in 1958 and is well up to schedule.

The Westfield plant will enable the gas industry to use low-grade coal with high ash and moisture contents in place of the scarcer and more costly coals traditionally required for gas making.

A second Lurgi plant is planned, this time by the West Midlands Gas Board, at Coleshill, Warwickshire. The pioneer work by The Scottish Gas Board at Westfield will almost certainly be followed in other British coalfields before long.

By the end of this year, Westfield is expected to be producing 15 mill. cu. ft/day of gas, and full output is expected to double this quantity by the end of 1962. The raw material is open-cast coal, which is extracted at an adjacent site and conveyed directly to the works, but low-grade mined coal may be used equally well.

An extensive grid system, without the need for expensive pumping and boosting installations, is being laid to distribute the gas over the whole of industrial Scotland, from Perth and Angus in the north-east through Kinross, Fife and Stirlingshire to Lanarkshire and ultimately to Ayrshire, the Lothians and the Border.

The obvious price advantage of siting a coal-gasification unit on the coalfield coupled with the minimum size requirements of processes using tonnage oxygen seem to render some form of gas grid almost imperative. It seems not too much to expect that in the future it may be economical to pipe gas under high pressure from the coalfields to centres of population such as London. The fact that the gas in the Lurgi process is generated at high pressure is an attractive feature in this respect.

A feature of Westfield is the "Tonnox" system for production and storage of the necessary oxygen. This allows a large amount of oxygen to be put into storage in liquid form, where necessary, enabling fluctuating demands to be met and ensuring that the gas-making process need not be interrupted even during several days of maintenance work.

A study of a projected Lurgi plant in the East Midlands[1] to operate at a load factor of 86·5 per cent, and consuming 1 mill. ton/annum of low-grade high-ash coal (35 per cent through $\frac{1}{8}$ in.), led to an estimated production cost of 8·59*d.*/therm. The process would include butane enrichment, the cost of the latter being taken at 7·5*d.*/therm. Typical volumetric compositions of Lurgi gas[1] are given in Table 1.

The cost of the raw gas was stated as 6·7*d.*/therm, and of the purified lean gas 9·1*d.*/therm. The cost of sulphur removal, carbon monoxide conversion* and partial carbon dioxide removal are respectively 0·6*d.*, 0·7*d.* and 1·1*d.*/therm.

The cost of reducing the toxicity of the gas† (namely, 0·7 + 1·1 = 1·8*d.*/therm) raises in the minds of the authors

* Conversion of carbon monoxide to hydrogen by the water gas shift reaction $CO + H_2O = CO_2 + H_2$.

† Recommended by The Gas Council for all new gasification plants.

TABLE 1.—*Percentage Volumetric Composition of the Gas at Various Stages in a Lurgi plant.*

Composition of Gas	Raw Gas	Purified Lean Gas	Final Gas
1	2	3	4
CO_2	29·0	17·5	16·4
H_2S	0·8	—	—
C_mH_n gases ..	0·3	0·3	0·3
H_2	41·0	64·7	60·5
CO	18·7	5·2	4·8
CH_4	9·4	11·0	10·3
N_2	0·8	0·9	0·9
O_2	—	0·4	0·4
C_2/C_4 gases ..	—	—	6·4

the question : " Is this too big a price to pay in view of the dire necessity of bringing down the cost of gas?" The authors have no detailed statistics to hand, but their impression is that the number of genuine fatalities resulting from the accidental inhalation of town gas is certainly no more than those resulting from oil fires and other like causes. Is it possible that the gas industry is too sensitive with regard to the toxicity of its product? The authors would concede that it is unfortunate that town gas contains carbon monoxide and that all that is reasonably possible should be done to prevent its accidental inhalation, but wonder if all other possible avenues (such as the introduction of a more distinctive odour, the provision of automatic ignition when a tap is turned on, gas warning devices) have been sufficiently explored. It is noticeable that considerable dilution of the final gas would be necessary before the concentration of carbon monoxide could be pronounced non-toxic.

V OTHER POSSIBILITIES : FUTURE DEVELOPMENTS

Dr. F. J. Dent[3] has shown that the methane produced in the Lurgi process results from the direct hydrogenation of the coal by some of the hydrogen produced in the water gas reaction. Laboratory investigations showed that the hydrogenation occurs in two stages, the first starting at 500°C, when the evolution of volatile matter becomes vigorous, and the second at the final steady temperature of the coke residue. Pilot-scale experiments with a fixed bed proceeded autonomously, but the methane yield was found to fall if the temperature rose too high. Experiments with fluidized systems at 25 to 50 atmospheres pressure and in two temperature stages at 800° to 850°C (volatile matter hydrogenation) and 900° to 950°C (carbon residue) facilitated temperature control. Dr. Dent has proposed two possible industrial processes. In the first, all the coal would be hydrogenated, and the residual char would be used to produce the necessary hydrogen, *via* water gas, as well as the steam requirement. In the second, the larger sizes screened from run-of-mine coal would feed a slagging-type fixed-bed gasifier to produce gas for hydrogenating the fines. The residual char would be used for steam raising. A hydrogasification plant, designed initially for treating oil, is under construction by Humphrey and Glasgow, Limited, at Partington, for the North Western Gas Board. It is hoped that it will prove ultimately possible to treat coal by this process.

An important limitation of the standard Lurgi process is the fact that sufficient steam (steam : oxygen ratio about 6 : 1 to 8 : 1) must be added to the blast to prevent clinkering of the fuel bed, and more than half of the steam supplied remains undecomposed. This limits the gasification rate, and on subsequent condensation it gives rise to an effluent disposal problem. Recovery of useful by-products from this material is costly. For these reasons, investigations have been made into the possibility of limiting the steam addition and allowing the bed temperatures to rise to a point at which the ash would be molten and could be removed as a liquid slag. An account of work carried out at Solihull is given by Hebden and Edge.[8] Further work has been undertaken by the British Coal Utilisation Research Association, in which it was further desired to introduce a proportion of the fuel, in a pulverised form, through the tuyeres. Neither of these investigations has yet reached a conclusion, but the process would seem to have promise. The type of gas analysis to be expected from a slagging producer is as follows, a standard Lurgi gas being shown for comparison.[1]

TABLE 2.—*Typical Percentage Volumetric Composition of the Raw Gas made by Slagging Gasifiers, compared with that made by the Standard Lurgi Gasifier.*

Composition of Gas	Slagging Gasifier	Standard Lurgi Gasifier
1	2	3
CO_2	4·7	29·0
H_2S	0·7	0·8
C_mH_n gases	0·2	0·3
H_2	25·6	41·0
CO	58·8	18·7
CH_4	9·0	9·4
N_2	1·0	0·8

It will be seen that the carbon monoxide content of the gas from the slagging gasifier is more than three times that from the standard Lurgi gasifier. If removal of carbon monoxide is regarded as imperative, this would add to the cost.

It is suggested that a further field for investigation in operating slagging-type gasifiers is the possibility of the simultaneous production of pig iron. One such process has been described by Wenzie.[4]

From the point of view of iron production, it has the advantage that it eliminates the coke oven stage, for the coal is charged direct to the furnace. This is made possible by the use of a " low-shaft " furnace (" bas-fourneau "), which, by reason of its smaller size, imposes a much smaller crushing stress on the lower part of the burden. Difficulties might arise in such a furnace if the coal is allowed to cake, but this is prevented by mixing together intimately the iron ore, lime and coal before charging. The charge must be smaller in size than in normal blast furnace practice, since the heat exchange between the coal charge and the hot ascending gases must be completed in a much shorter distance; therefore, the material is graded 0·2 to 1·0 in. The iron ore must be of the ferric oxide type, for this pre-oxidizes the coal and greatly reduces its caking properties. The charge is fed into the furnace continuously, and slag and iron flow from the bottom without interruption. A special difficulty in the development of this process has been the carry-over of dust mixed with tar acids. This has been overcome by using a " hot-filter " containing iron oxide and maintained at 700°C. This removes the dust and converts the tar acids into light oils, which are much more easily dealt with. The iron oxide is removed from time to time, and is added to the material about to be charged to the furnace.

If an oxygen blast were used, with appropriate steam addition, it might result in a gas of sufficiently high calorific value to be of interest, with further enrichment, to the gas industry, and a relatively small rate of iron production could have an important bearing on the economy of the process.

There are many other possibilities or variants, which should be watched. Examples are the Otto-Rummel double-shaft gasifier. This is steam-blown, the coal being introduced

with the steam and directed at the molten slag. The make gas ascends one of the shafts, and the pool of slag, common to the bases of both shafts, circulates between them. The necessary heat for reaction is provided by directing an air jet at the slag below the second shaft, some of the coal carried in the slag being thereby oxidized. In this process, the slag serves to conduct the reaction heat to the endothermic zone. Another possibility, in which the fuel itself does this, is the case of two fluidized-bed reactors in tandem, one-steam-blown, and the other air-blown, the fuel being continuously withdrawn from each vessel and introduced into the other with the fluid stream.

A noteworthy development in processes ancillary to gas generation is the underground high-pressure storage scheme undertaken by Imperial Chemical Industries and the Northern Gas Board. If the scheme is successful, and other similar efforts made, it could, in conjunction with high-pressure gasification, provide valuable and cheap peak-load capacity.

VI CONCLUSIONS

It would seem that if the gas industry is to continue to make an important contribution to Great Britain's fuel economy, as in the authors' view it must, then the immediate future must see more and more development work for the evolution of new processes, aimed at the production of cheaper gas. The proportion of coke produced may be expected to decline.

At the moment, there are available a number of economic processes for total gasification of oil. Such processes may be expected to form a permanent feature of the gas industry, and, in the long term, are desirable from the point of view of conservation of world fuel resources. It seems likely that valuable fuel potential based on petroleum would be wasted if some of it were not converted to gas. At the same time, it seems highly desirable that the future gas industry should be based to a large degree on this country's indigenous fuel, coal. This is desirable not only because of the possibility of being cut off from supplies of other raw material in the event of world conflict, but also on the grounds of the general economy of the country. The latter aspect is of further significance in the light of the coal industry's present difficulty in recapturing former foreign markets.

At the moment, the only process capable of commercial application to coal is the Lurgi, using a fixed bed and an oxygen/steam blast. It is restricted for economic operation to large units, operating at high load factor, near, or preferably at, the pithead. Since it operates at high pressure, it is eminently suited to supplying a gas grid, in which gas may be transported over (comparatively) great distances. However, a number of interesting possibilities, notably variants of the slagging gasifier, are in the offing, and it is to be expected that some, at least, of these will be proven. The possibility of attaining greater economy might be realized by the combination of gas making with the smelting of ore.

Considerable saving in gas generating cost would be effected if it were decided that the toxic nature of town gas must be accepted as a condition uneconomic to remove.

It is significant that all the new processes for gas generation immediately available have been initially developed abroad. This points a lesson of the past ; industry in this country, and especially that section of it connected with gas manufacture, cannot afford to neglect development work.

Literature References

[1]Report of the Committee on Coal Derivatives. Chairman, A. H. Wilson, F.R.S. (H.M.S.O. Aug., 1960).

[2]Dent, F. J. *Gas Council Res. Comm. GC*1, Nov., 1952. Also, Ninth Coal Science Lecture, "The Hydrogenation of Coal to Methane", to be published by B.C.U.R.A.

[3]Hebden, D., and Edge, R. F. *Gas Council Res. Comm. GC*50, 1958.

[4]Wenzie, W. *Proc. Inter. Conf. on Total Gasification*, Liege, 1954.

PRESENTATION, DISCUSSION AND REPLY

Presentation

Dr. C. Hulse presented this paper and summarized its contents.

Mr. D. E. Rooke (London) :—In this paper, Professor Thring and Dr. Hulse have discussed gas making against the background of the national fuel situation in the next 25 years, as they see it. This consideration has led them back to what is really the starting-point of the paper presented by Sir Harold Hartley,* namely that the gas industry must be revitalized by new processes stemming from an intensive research and development effort.

Throughout the paper, many references are made to the work of the Committee on Coal Derivatives, whose Report was published in August, 1960. Amongst the conclusions of this [Wilson] Committee, one finds the following words : "Within the field of our enquiry, town gas offers the greatest scope for expansion, but to make this possible new plants will have to make gas more cheaply than existing ones." This is both encouraging and at the same time challenging. It offers hope for the future, but conditional upon the achievement by the industry of certain research and development objectives.

The Authors have called attention to the fact that the industry draws its raw materials, coal and oil, from its competitors. Furthermore, these substances, which are raw materials to our industry, are, in fact, the finished products of our competitors, and this is an important point. Town gas is a premium fuel and we cannot expect it to compete for those heat services where its unique properties cannot command a premium. If a supply of bulk heat is required, and the sulphur content of the fuel is of no consequence, then clearly town gas made from fuel oil cannot compete with the fuel oil itself.

Particularly in the domestic field, convenience to the customer can command a premium, but the size of this premium is at present in some doubt. That sales of gas have not expanded in recent years like those of electricity and oil products, has been mentioned, and the Authors have quoted again from the Wilson Report in saying that it is the opinion of The Gas Council that the total cost of manufacture of gas should not exceed 10*d.*/therm, inclusive of capital charges. This statement of the Council's opinion appears in the detailed conclusions at the end of the Report, but I would draw attention to the original statement of the Council's opinion, which appears in paragraph 45. Here it will be seen that, although an upper limit of 10*d.*/therm, including capital charges, was mentioned, the Council said also that the cost of manufacture "should preferably be substantially less" than this if the period of static gas sales was to be ended, and the figure of 10*d.* cannot be taken as the real target at which to aim.

Dealing with the possibility of departing from the present standards of town gas, the Authors give their opinion that the industry should be prepared to face the prospect of changing jet

* The Choice of Subjects for Research and Development. Hartley, H. Comm. 578; J.I.G.E., 1961, 1, 3 to 20

sizes of existing appliances if non-standard gases could be produced very cheaply. This prospect is certainly not preventing the industry from giving thought to the production of non-standard gases and has already been faced from time to time in the life of the industry. However, the departure from "normality" that can be accommodated in this way is somewhat limited and some gases might require radical changes in the combustion chamber design of many domestic appliances, particularly water heaters. Incidentally, the estimate of £10/consumer given in the Wilson Report was an attempt to illustrate the cost of such a radical change in the gas type.

Turning to the more detailed consideration of the Lurgi process, and, particularly, the study of a Lurgi plant sited at the pithead, I am sorry to see that the Authors cast doubt upon the commercial wisdom of reducing the carbon monoxide content of the gases distributed. Of course, more can be done and, in fact, is being done to make appliances safer and so reduce the risk of accidental gassing, but, in my opinion, this is not a field in which the industry can refrain from making advances merely because they increase the cost of the final gas.

The Authors were quite right to draw attention to the heavy burden imposed by the present cost of operating the shift and carbon dioxide removal processes, even at high pressure, but the conclusion that I prefer to draw is that much more intensive development of these gas-treatment processes is required before we can feel satisfied. I feel certain that The Gas Council will persist in the course that it set itself after careful and deliberate consideration of the whole matter.

So far as the present study is concerned, the Authors may have overestimated the savings likely to accrue from the deletion of the carbon monoxide conversion stage.

Firstly, the saving of 1·8*d.* quoted is per therm of purified lean gas and would be less per therm of final gas.

Secondly, assuming that the calorific value and gravity of the final town gas are to remain unchanged, it will be necessary to remove very nearly the same weight of carbon dioxide from the unshifted Lurgi gas in order to meet the specific-gravity limitation. Since the final carbon dioxide content would have to be much lower than in the quoted gas, the total cost of carbon dioxide removal could be taken as about equal in both cases, and thus the saving that would accrue would be much reduced. If the specific gravity were not to be held constant, then I estimate that a gas of 500 Btu/ft³ of comparable gravity to the carbon monoxide-rich town gas could be produced at identical cost by the addition of nitrogen/butane mixture to the standard final gas.

The development of slagging gasifiers received much attention from the Wilson Committee, whose members felt that it represented a most important aim of research. As Sir Henry Jones, M.B.E., stated in his contribution to the discussion on the paper by Sir Harold Hartley, the Council fully accept this point and will continue to conduct research to this end, although the economics of the process are not obviously advantageous. For general use, the high carbon monoxide-content gas arising from such a gasifier cannot be distributed without shift conversion, although the possibility of using such gas for industrial purposes remains. So, too, remains the possibility of coupling this process to that of iron production, but my personal opinion is that the engineering difficulties of slagging gasification in oxygen and under pressure for town gas production are such that the effort should first be concentrated on the simpler objective until an appreciable measure of success has been achieved. Once a fully satisfactory pilot slagging gasifier is available, a number of possibilities for integration can be investigated on a practical scale.

The industry is not short of possible processes at the present time, but is certainly not able at this moment to deploy one that would be the obvious answer to all difficulties. That most of the processes available were originally developed abroad is surely a reflection of the fact that the carbonization technique has remained economic for longer in the United Kingdom than in many areas abroad, particularly those where sources of natural gas and cheap oil products suddenly erupted to disturb the balance of the fuel economy. The Authors must not be allowed to suggest that all new processes are of foreign origin: for example, basic experimental work for the "Segas" process was not only performed in this country, but the technique grew to full industrial scale here; that it found its most numerous applications abroad is only one of the problems to be faced by the prophet at home. On the same note, it must also be agreed that the processes currently under investigation in The Gas Council's laboratories are at least as imaginative as those under development in similar laboratories anywhere else in the world.

In their conclusions, the Authors refer to the Lurgi process as being the only commercial process now available for application to coal, but appear to imply criticism of its fixed-bed nature. Although various types of fluidized and entrained fuel gasifiers have been proposed, the fixed-bed reactor has the unique advantage of true counter-current operation, which may well be of great advantage in processing coals. Certainly, this principle should not be abandoned merely because it is fashionable in other places to do so.

Mr. L. W. Andrew (London):—This is a provocative paper. I accept the statements on the general advantages of gas, which are very fairly laid down, and the fact that the opportunity exists for a rising standard of heat services, and that the gas industry's share in this increasing load will be bigger as gas becomes cheaper. I accept all this, but it should not blind us to the present position.

On the first page of the paper, there is a rather sweeping statement: "... it is apparent that everywhere coal is cheapest and gas more expensive than oil". I do not believe that this is a fair overall statement of the present position. Quite clearly, one must look for a reason for such a discrepancy. What has really happened is that the information on which the paper is based is not completely up to date: it does not fully take into account the latest appliances and the latest tariffs available. There is a great danger of our being hypnotized by surveys carried out in the past—excellent surveys, but surveys that did not take into account the very latest developments. There is also a danger of our being hypnotized by the mysterious term "useful therms". What really matters is the actual service given to a user, and what the user will pay for it; it is the flexibility of gas, which is so difficult to express on paper, that makes such a very real difference in practice.

With current prices of gas, we might well look at two types of heat service. There is the one that is the major heat service, in which the total cost of running, capital and maintenance, is of very great importance; then there are the smaller services in which marginal running cost differences are unimportant. To quote specific examples of living-room heating: there are a great number of open coal fires, and it is true at the moment that the modern high-efficiency convector fire, properly installed, can replace an open coal fire in practically every part of the country without any increase in running cost; this is a very great thing. Selective warm-air heating, which is modern, has given a service that is completely acceptable to the user and is economic in its use.

On the central heating side, the running cost is a little more difficult, but here it has been shown quite clearly that, if one takes capital, maintenance and running costs into account, the position is sufficiently competitive for gas central heating to be very popular. As to water heating, we have the interesting difference between the provision of what a person really needs and wants and what he may be forced to take with, say, a central service; it would be wrong to say that gas is not competitive with electricity at present prices at the sort of level of water usage many people want—possibly 150 or 140 gal.

We should remember that with such appliances as cookers, refrigerators, dryers and incinerators, for which there is no alternative fuel, a marginal difference in running cost, one way or another, does not matter. It is the service that matters.

I feel strongly that, at this stage of our work, statements of this sort should be made. It is probably right to say that the evidence for these statements is based on practical experience on the district: for example, The Gas Council collaborated with the Gas Boards in field trials in about 120 houses, in which direct heating comparisons were made between a high proportion of solid fuel, little solid fuel, and all-gas. The results have not yet been published, but they have been analysed, and I hope they will be published soon; they show that the all-gas installation over all the 12 Area Gas Boards was competitive with those including a high proportion of solid fuel. There are instrumented houses and flats at Headstone Lane and West Ham and Gateshead, the results of which have been given to the Institution, and I hope that many members of the Institution heard a paper given to the recent Public Works Congress in which figures were released for the flats and houses at Harlow

is which the use of gas for instantaneous water heating and warm-air heating proved to be competitive to the users.

With this sort of background, one cannot accept the statement that even at the moment gas is more expensive than oil or solid fuel. This immediately raises the difficult question : " Why, in that case, is the consumption of gas not rocketing?"

Partly the answer is that the gas industry has only recently fully appreciated its own strength. We are better than we think so far as service to the user goes. Secondly, it is only recently that the gas industry has felt the impact of newer plants and improved methods of appliance installation. One can prove this by the resurgence of selling and popularity of gas that has taken place over the last year. There are real indications that there is a change, and Sir Henry Jones, M.B.E., mentioned yesterday a 4 per cent rise in gas consumption since between April and November, 1960.

I shall not talk about research and development, except to say that the paper underestimates what has been done. The various new appliances and methods have shown great progress.

The gas industry's sensitivity to the toxicity of gas was dealt with admirably by Mr. Rooke. I would say that we are very sensitive—and thank God that we are! This is a question not of sensitivity, but of responsibility. I am not thinking of the relative number of accidents, but of the actual number. I am very glad that Mr. Rooke has confirmed The Gas Council's attitude to this matter.

Automatic ignition is a means to an end. It has absolute priority. Since 1959, for example, it has been mandatory for the hotplates of all cookers. The right approach is to set a target, remembering that with a refined fuel cost is not necessarily the only factor to be considered. With a refined fuel, one must look for the best possible service. I like to feel that the gas industry has such a target, that its sights are set high, so that, looking ahead, it is thinking in terms of low carbon monoxide, low sulphur, and absolute consistency of quality of the product we sell. I have such faith in our engineers that I believe that, given this target, they will achieve it by the additional research and development that Mr. Rooke mentioned.

Mr. L. J. Clark, B.E.M. (London) :—It is always stimulating to the gas industry to have presented to it the views of an outside authority able, perhaps, to stand back and take a wider perspective of the fuel industries as a whole. Perhaps it goes a little way towards enabling us to do as Rabbie Burns pleaded, " to see oursel's as ithers see us ". This paper, coupled with that by Sir Harold Hartley, does help us in this direction.

At an early point in the paper, reference is made to two anomalies in the gas industry ; first, that it is a dual-fuel industry, and, second, that it buys its raw materials from its competitors. I would suggest that there is a third and important one, that the gas industry is dispensable, whereas the other industries, particularly electricity and oil, are indispensable. Oil has a complete monopoly so far as automative fuel is concerned ; electricity has a complete monopoly in certain uses for power production, and so on. Gas can hold its place only on the basis of true economic supply of heat and on the service and quality of its product.

Looking at quality for a moment, we think of three things : sulphur, carbon monoxide and Wobbe Number and combustion characteristics.

I think that all gas engineers are giving more attention to sulphur these days. I can remember presenting a paper on the sulphur problem and what could be done in the industry as at that time. When my co-author and I presented that paper, we were told that we were " flogging a dead horse", but, when I heard Sir Harold Hartley's presentation, I thought of this as a case of operational research and looked at the figures to see what had happened in the North Thames Gas Board's installations since that time. In 1957, the total sulphur in the Board's gas was 17·9 gr/100 ft³. In the following year, it was 15·8, and in the next year 13·9. In the year up to March, 1960, it was 11·4 gr/100 ft³. The present indications are that we may get somewhere near a target of 10 gr/100 ft³ within the foreseeable future. This has been done on existing plant by altering it in a particular way.

Much has been said about reducing the carbon monoxide content of town gas, and I do not think that we should be carried away too far by the suggestion that it is a very expensive operation : it depends on the gas-producing process used. We have examined certain cases where the cost of carbon monoxide removal can be below 0·25*d.*/therm, especially when one is producing a light gas, which makes it unnecessary to remove the carbon dioxide. We should set the target there for improving quality.

Every engineer in the gas industry hears the term Wobbe Number every day, and we have at present many more techniques and alternative gases and alternative ways of enabling a client to exercise control over the gases supplied.

The Authors refer to the gas industry's problems in selling coke at present, and they point to the very much more satisfactory progress made by specialist fuels. The point to keep in mind here is that the specialist smokeless fuels represent only some 10 to 15 per cent of coke production. Surely, if one is working in a small marginal market of this sort one will have no difficulty in selling the material. The gas industry is now following the example set by others and is making special cokes itself—and finding that they are selling extremely well.

The Authors have painted quite a bold picture for the future prospects of the industry. They have reviewed the various methods that we have available for producing gas at an economic price. I think that we are now beginning to know them all. The production of gas from coal at the pithead—where we see that it can be done at quite favourable costs ; the production of gas from oil and its products, and even the importation of liquid natural gas to strategic places in the country, based on ports and refineries. With a grid link system coupling these together and with the possibilities of the introduction of underground storage, the whole system could be integrated to be economically attractive.

In many instances, we tend to try to weigh up the advantages of one process *versus* another, not always with sufficient factual information as to how those processes really fit in the industry. I feel that each of them offers such possibilities that the industry should adopt them all, developing the large pithead coal-gasification plant up to a scale where it is really reaching its commercial optimum from the economic point of view—and the same with the oil-products plants. We should also, if possible, go for liquid methane to the scale on which it is commercially economic. When that has been done, the industry can look at all those processes and really compare them on a factual basis, and from that stage on any one of them can be taken a further stage and really be assessed effectively against the others.

A great technical change has come to the gas industry. It is, of course, the biggest single new circumstance in the whole of its history. The industry, from the technical point of view, with limited technical resources (we must accept this, for the technical resources are still geared to the old carbonizing days), is facing this change in a fairly bold manner.

I should like to leave the thought with the Authors, who come from the centre of the steel industry and have suggested that gas and coke will still be made in the steel industry for a long time, that the British steel industry is going to be more and more affected by competition from overseas and that alternative methods of ore reduction will have to be considered very seriously, by which hydrogen and other means of reducing ore will have to play a part, and that this " wind of change ", which has come very suddenly on the gas industry, may be only round the corner for the steel industry.

Mr. W. Hodkinson, O.B.E. (Manchester ; Deputy Chairman, North Western Gas Board) :—The paper by Professor Thring and Dr. Hulse poses many questions that are uppermost in the minds of the majority of gas engineers, and the paper makes some useful contributions to their thoughts on this subject. I fear, however, that it will be some time before any of us will be brave enough to set down on paper a composite plan for the pattern of gas making in Great Britain 25 years from now. I agree with Mr. Clark that we have many processes that can be brought to our aid immediately, and we should try them all.

In the meantime, and apparently contrary to what is the accepted view, we do make substantial progress in many fields of our endeavour, particularly in the industrial field, where, contrary to the statement in the paper on the subject of price, we can offer a cheaper overall service to the manufacturers in many fields of utilization, and there we can compete to great advantage.

Similarly in the domestic heating field, up to a rating of somewhere round about 6,000 Btu/h, with modern tariff structures we have a very definite advantage against all our competitors ; and this is a field with a potential demand of some 30 mill. tons of coal.

or something like twice, or more than twice, the present gas output of the British gas industry.

We have made tremendous strides in the field of appliance development by raising their overall efficiency of utilization, and we should bear in mind that the very substantial improvements create a very substantial reduction in the net cost of the energy we supply to our customers. In fact, many pennies per therm have been taken off the net cost of the energy by the use of these appliances.

With regard to solid fuel, there is a sign that, within the next two years, we may have to be thinking about making additional quantities of solid smokeless fuel to meet the demands which have been created by the Clean Air Act. We must remember that solid smokeless fuel can play a part in developing clean heat in the home. It can tide us over the period when we have to overcome the resistance of the domestic user to the loss of the solid-fuel coal fire.

My colleagues who preceded me in the discussion have referred to the suggestion that we are over-sensitive about carbon monoxide in town gas. I, personally, am appalled at the idea that we should not give this subject the greatest attention. We must realize that it is the customer who matters ; that the customer is sensitive to the danger of town gas as we supply it, and that toxicity is having an effect on the development of the industry and on the development of our load. Therefore, I was delighted to hear from Mr. Rooke that we will continue to press forward with the finding of a solution to this problem.

I have found the paper most interesting and provocative—but to be provocative is, after all, one of the purposes of our Meetings.

Dr. J. H. Towler (Harrogate) :—This paper is a fair summary of current thought on the developing pattern of the gas industry ; indeed, one can already see the picture taking shape in the progressive concentration of production at larger, more efficient works, the planned and already constructed Lurgi plants at Coleshill and Westfield, respectively, and the spreading networks of the gas grids.

It seems clear that the industry will continue to be based upon the country's indigenous resources of coal, with increasing emphasis upon complete gasification of low-grade material. The Lurgi represents the most advanced plant at present available ; it has considerable disadvantages, however, notably the need for hydrocarbon enrichment of the gas before distribution, the large steam requirement, and the large volume of effluent produced. One awaits with great interest the outcome of work on the production of a rich gas by hydrogenation of coal. So far as the effluent is concerned, the disposal of this is surely to be regarded as a legitimate charge upon any process, and I am wondering whether this has been taken into account in the cost given for Lurgi gas. Perhaps the Authors could give an estimate of the effect upon the price of the gas for the worst case in which a works operating Lurgi plant had to treat all its own effluent.

On the brighter side, it seems that the possibiiity of supplying gas of relatively constant combustion characteristics may eventually become a reality. In addition, one foresees the town gas distributed free from objectionable condensable and unsaturated compounds and organic sulphur. Considerable importance should be attached to the latter, and I suggest that an additional argument for carbon monoxide reduction, if not complete removal, is contained in the fact that the organic sulphur content of a gas is reduced after treatment over a water gas shift catalyst. I should welcome the Authors' comments on these points.

Finally, and very briefly, I should like to mention the reforming of hydrocarbons with steam to meet peak loads. The North Eastern Gas Board recently commissioned a " Hercules " plant for the continuous reforming of natural gas. Having some acquaintance with this plant, I think that, whereas the cyclic processes will continue to be operated on liquid feedstocks, the inherently simpler continuous reforming processes have advantages when the feedstock is gaseous, and may well become important in the future.

Mr. K. Francombe (Darlington) :—May I be a little less gentlemanly than my predecessors in this discussion? I must confess that, having read the paper, I did not find the usual stimulation experienced when hearing the Authors' contributions and papers concerning the steel industry. In this paper, I can quite frankly find practically nothing new. It is a recital of what has happened and appeared in other places, and, indeed, I find that certain remarks are made which one might criticize.

For example, in the Introduction, the fact that water gas production is only about half of the theoretical capacity of water gas plant is not really a statement of why water gas plant cannot be used for base-load gas; if it is not used at less than its maximum capacity, then what is available for peak-load purposes?

In Section II, I find the rather unusual statement that " factors other than relative costs also mitigate against town gas". I am not clear on the use of the word " mitigate " in these circumstances. In Section III, I find that the Authors think it a pity that the Clean Air Act does not enable anything to be done about the emission of sulphur dioxide from chimneys. I suggest that everybody is aware of the enormous tonnage of sulphur dioxide emitted, but that the reason the Clean Air Act does not incorporate any measures against this is because there is no satisfactory process yet evolved that will, in fact, remove sulphur dioxide from the flue gases of power stations.

In the description of the Lurgi process at Westfield, it would be for The Scottish Gas Board to correct the Authors, but, as it has not yet done so, do I not gather that this plant is washing out the carbon dioxide, not by water under pressure, as was a perfectly feasible method, but by the Benfield process, using hot potassium carbonate?

Towards the end of the paper, it is stated that, in the event of world conflict, it would be desirable to have our own indigenous supplies and not to be dependent on imported basic materials, oil, and so forth. But, quite honestly, I feel that in the event of a world conflict it does not matter very much whether our fuels are imported or are produced at home. I cannot see much future for fuels in a world conflict.

Finally, I should like to elaborate a little on the question of carbon monoxide removal, which has been mentioned by all those who have taken part in the discussion. Apart from the fact that, with the standard Lurgi gas, 18·7 per cent is given by the Authors as the carbon monoxide content, the carbon dioxide content, even before conversion, is 29 per cent. It seems to me, as Mr. Rooke has already said, that much of this carbon dioxide will in any case have to be removed to provide a satisfactory Wobbe Number and combustion characteristics generally. As the carbon dioxide removal stage is by far the more expensive of the two stages, the gas would not be appreciably cheapened by the omission of the carbon monoxide reduction stage even though the resultant carbon monoxide content of perhaps 23 per cent (corresponding to a carbon dioxide content of, say, 9 per cent) were tolerated. If one goes on to the slagging gasifier, where there is 58·8 per cent of carbon monoxide, I do not think anybody could consider distributing town gas that contained 58·8 per cent of carbon monoxide, because it would be much more lethal than blast furnace gas—and we all know the accidents that occur in steelworks with gas of this high carbon monoxide content, admittedly aggravated by its high specific gravity.

Regarding carbon monoxide removal in general, I think it is important to follow on what has been said elsewhere, which is that existing gases may often be carbon monoxide reduced without removal of carbon dioxide, because most gases that might be so treated, including water gas, would still result in town gas with less than 20 per cent of carbon dioxide. If the gas has below 20 per cent of carbon dioxide, both its corrosive and combustion characteristics should be reasonably satisfactory, and others have worked out a number of cases where one can convert carbon monoxide to hydrogen, and still get back to a satisfactory Wobbe Number within the gas group concerned, without removal of carbon dioxide, but restoring the calorific value of butane. In view of the relative cheapness of butane, it should then be possible to carry out the reduction of carbon monoxide at small cost, because the carbon monoxide conversion process in these circumstances will produce more product gas than one put into the carbon monoxide convertor. This extra product gas is supplied free. So one finishes up with a gas, of reduced toxicity, that has cost very little extra.

Written Contribution

Mr. B. Richardson (Newcastle-upon-Tyne) wrote :—Whilst reading the paper by Professor Thring and Dr. Hulse, I was reminded of the American aphorism that states " Never prophesy unless you know ". for anyone who at the present time attempts to predict the probable trend in the British gas industry over the next quarter of a century is very daring indeed. When one looks back to 1935,

for instance, and considers how wide of the mark were most of the forecasts then made regarding the industry's future, owing to unforeseen events, how much more so is the case today in a world economy that changes with unprecedented rapidity and when new techniques spring up almost overnight.

The aim of the gas industry is to supply cheap gas of a quality satisfactory to the consumer, and at the moment it would appear that the total gasification of petroleum oils or coal provides the best means of achieving this. Unfortunately, all these schemes yield a product containing a relatively high proportion of carbon monoxide at a time when serious consideration is being given to means for reducing the amount of this toxic constituent in town gas. Although I believe that the dangers inherent in distributing a gas containing 10 per cent or over of carbon monoxide are greatly overrated, I nevertheless do not agree with the Authors that its elimination is too big a price to pay in view of the necessity for bringing down the cost of gas, for, as an old brochure on "Water Gas", published in 1897, succinctly, if somewhat sonorously, puts it: "The carbonic oxide superstitution . . . was utterly dissipated by both practical and scientific verdict many years ago, but not before it had transgressed public intelligence to an extent which perhaps explains its passing recrudescence here".

In this consideration, it would be interesting to learn what concentration of carbon monoxide in gas would be regarded as non-lethal.

Apart from its poisonous nature, carbon monoxide is a very useful constituent of gas. It possesses a high flame temperature and, when burnt in air, yields carbon dioxide only, whereas all other combustible components of coal gas (or oil gas) yield water vapour as well. Thus, by detoxifying gas and substituting hydrogen for carbon monoxide, one either loses more heat in the latent form as water vapour when the gas is burnt or increases the tendency for corrosion to occur in certain gas appliances, due to the increased amount of condensed water produced therein per unit of gas consumed.

The Lurgi system of complete gasification of coal appears to me to be satisfactory up to a point, but it has yet to be shown that it can produce gas at a price of 10*d.*/therm. Perhaps the least favourable feature about it is that it demands expensive plant to extract oxygen from the air, and then more expensive plant to remove the oxygen again in the useless form of carbon dioxide. However, the plants at Westfield and Coleshill will doubtless clarify this and kindred matters in the near future.

One potential source of future gas not referred to by the Authors in their paper is methane produced from the fermentage of sewage. It has been stated that if recovery were extended to approximately 35 mill. of population, 30 mill. cu. ft of gas containing 75 per cent of methane could be obtained per day. Assuming it to possess a calorific value of 700 Btu/ft,[8] this would be equivalent to 200,000 tons/annum of coal—quite a valuable contribution to the national economy.

The significance of the figures in Section III of the paper, which show the hydrogen to carbon ratio of various fuels, is obscure. Actually, they represent the weight of hydrogen as a percentage of the weight of carbon in these after allowing for "locked up" hydrogen, and are not a ratio by weight of hydrogen to carbon as the wording would lead one to believe.

The Authors, in their final paragraph, would appear to suggest that development work in connexion with gas manufacture has been somewhat neglected by this country in recent years, all new processes having originated from abroad.

I suggest that the reason for this is not remissness on our part, but is due to the fact that, until quite recently, modern coal-carbonizing plants of the "conventional" type provided us with the cheapest gas. In those countries, however, where coal is either non-existent or consists mainly of low-grade and non-coking varieties, there has been every incentive to develop such gasification processes as the Lurgi or catalytic oil-gasification plants exemplified by the Onia-Gegi system.

Written Reply

The **Authors,** in reply, wrote :—The Authors wish to take this opportunity of thanking all who were kind enough to contribute to the discussion of their paper. Our aim was to be provocative, and, it would appear, we succeeded in at least one particular.

Most speakers made reference to our comments on the removal of carbon monoxide from town gas. Let us hasten to say at once that we favour its removal, provided that this can be done at a not too excessive cost. Danger exists in every sphere of modern life : although one deplores its toll of human life, there is a limit to the safety measures that may realistically be applied. Would one advocate that electricity be distributed at a pressure of only 20 V, or should we return to the situation of a man with a red flag having to precede our modern "horseless carriages"? Both measures would reduce accidents to the public, the latter by a number greatly in excess of accidents due to carbon monoxide poisoning, but few would be bold enough to advocate them.

The Authors would agree that every effort should be made to reduce the cost of carbon monoxide removal, but still feel that 1·8*d*/therm, the figure quoted in the Wilson Report, is too high a price to pay. They venture the opinion that the average customer of the gas industry, both industrial and domestic, would think likewise, provided the facts of the matters were suitably presented. In this connexion, there is perhaps need for re-education of the general public, though we have surely progressed from the comments of the 1897 brochure on water gas, referred to by Mr. Richardson. We would thank Mr. Richardson for mentioning some of the technical advantages of carbon monoxide composed with hydrogen.

With regard to Dr. Towler's point on the partial elimination of organic sulphur in company with carbon monoxide by means of the shift reaction, this is certainly a point in its favour. However, the sulphur content of town gas is already so low that its further reduction is of only marginal benefit when regarded from the point of view of general pollution due to sulphur dioxide.

We regret that Mr. Francombe misunderstood our remarks on removal of sulphur dioxide and on the Clean Air Act. The impression we were trying to convey was that, since town gas is nearly sulphur-free, this is a weighty point in its favour when compared with the use of alternative sulphur-containing fuels. We would not agree that it is technically impossible to remove sulphur dioxide from the waste gases of power stations. It is, however, costly, and, despite its deleterious and, from time to time, deadly effects on human health, its removal is not as yet required by law. In the industrial domestic fields one could argue a case in favour of the use of town gas in preference to solid fuel, on the grounds of negligible sulphur emission. Regarded as a would-be problem, one might even suggest a graded tax on the use of all fuels on the basis of sulphur content : in the national context, it might be crippling in its effect on export trade.

A number of speakers, including Mr. Rooke and Mr. Andrew, pointed out that town gas is a premium fuel : its value to the user cannot be assessed solely in terms of cost per useful therm. The Authors wholeheartedly agree. However, there is a limit to the extra price that its undoubted advantages warrant. Present indications are that, in general, this extra price is a little too much. If gas is to enhance its position relative to other fuels, its cost must be reduced. Surely technological effort and ingenuity is adequate for the task.

51st REPORT OF THE JOINT REFRACTORIES RESEARCH COMMITTEE: 1959-60

RESEARCH COMMUNICATION GC71 (CONCLUDED)

TABLE OF CONTENTS

	PAGE
VII Progress Report of Other Investigations :	502
(1) Field Trials on Flaking and the Effect of Iron Spots	502
(2) The Activation of Coke	504
(3) The Measurement of Tensile Strength of Refractories at High Temperatures	505
(4) A Study of Spalling	505
(5) A Study of the Properties and Behaviour of Mouldable and Castable Refractories	506
APPENDIX	
Papers of the British Ceramic Research Association, published since the 50th Report of the Joint Refractories Research Committee, of interest to the Gas Industry	506
Introduction, Presentation, Discussion and Reply	507

VII PROGRESS REPORT OF OTHER INVESTIGATIONS

(1) FIELD TRIALS ON FLAKING AND THE EFFECT OF IRON SPOTS

(a) Flaking Trials

Inspections of retorts containing the special silica materials have been carried out at three Works in the North Western area. Several, or all, of the trial retorts at these Works were scurfed together so as to allow each group to be studied together and the conditions of individual retorts to be compared.

Before the results are discussed, it is desirable that the unsatisfactory nature of these visual inspections from the top of the retort should be stressed. When looking down into one of these trial retorts, the observer is aware that the wall that he sees contains four panels in the special materials. He cannot normally locate them by counting or identifying courses, because of the poor viewing conditions, and he cannot be certain that the flaking zone corresponds with the trial area in either position or extent. Under these conditions, the observer tends unconsciously to divide the flaked area into four imaginary rectangles, which he identifies with the panels. If the flaking zone does not in fact correspond exactly with the trial area, this mental division may be quite misleading. Errors of evaluation due to mis-location of the trial area are, of course, separate from, and additional to, the uncertainty in assessing depth of flaking.

Works 1

In these upwardly heated retorts, the flaking zone began some 8 ft from the top of the retort and appeared to extend to about 15 ft from the top. It was beyond the reach of the profile gauge, and did not show clearly on the photographs that were taken, because the retorts were quite hot and were consequently brighter at the flaking level than the light reaching that point from the flash bulb. Two observers made a careful visual inspection of both faces of each retort and in general agreed in their impressions. Some of the assessments were easy in that an area covering half the width of some faces was obviously much more or much less flaked than the corresponding area at the same level. This type of distribution clearly delimited one part at least of the trial area and gave a clue as to the position of the whole area with respect to the flaking zone. Where such clues were absent, the difficulty of "placing" the panels in the flaked zone became apparent and the assessment of the relative degrees of flaking was very uncertain. Furthermore, the faces on the platform side could not be seen in full. The angle of view was very narrow and only half the visible area could be seen at a time, by looking alternately from one end and the other. Neither observer was prepared to draw up an order of merit for two of these faces.

The following placings were recorded :—

Material A Appears in six faces. Placed first three times (superior to D in one face), joint third twice, fourth once.

Material B Appears in seven faces. Placed first once, second or joint second three times, third or joint third three times.

Material C Seven appearances. Placed first once, joint second once, third or joint third five times.

Material D Six appearances. Placed first three times (outstandingly best in two faces), second or joint second three times.

Material E Six appearances. Placed second once, joint third once, fourth four times.

The erratic scoring of some of the materials (particularly A) illustrates the uncertainty of the observations, and in view of this uncertainty it would be unwise to draw up a full order of merit. There can be little doubt, however, that material D has on the average flaked least and that E has

flaked most. To this extent the observations confirm the order given in the last Report.

Works 2

In these upwardly heated retorts, flaking was very light indeed and on some faces the only flaking to be seen corresponded with the position of material E. The only conclusion to be drawn from these observations is that E is the least resistant to flaking of the five trial materials.

Works 3

In these downwardly heated retorts, the flaking zone appeared to be very narrow, and visual assessments of the relative degrees of flaking, made with the inevitable mental bias towards dividing the flaked zone into four equal areas, were extremely difficult since no lines of demarcation corresponding to such areas could be seen. It has since been found, by studying photographs of two of the faces, that at the present stage of the life of these retorts the flaking zone does not extend beyond the top trial panels on most of the faces, and both observers' assessments were quite wrong in most instances since they were based on fallacious assumptions regarding the positions of the trial materials. They will not be reported here.

The profile gauge was applied to several faces and indicated a narrow band of flaking with a maximum depth of about ¼ in. Unfortunately, the gauge could only be used over a small proportion of the retort width since the retorts were 76 in. wide and the top opening was only 30 in. wide. For this type of retort, it would be necessary to employ a cranked handle to reach the central zones of the trial panels.

The management at this Works had been most helpful in cooling down the retorts for this inspection to a temperature that appeared to be below 900°C. As a result, the lighting conditions for photography were excellent. Unfortunately, the working conditions above the retorts were extremely unpleasant in spite of the management's thoughtful provision of a large cooling fan, and only two retorts were photographed. The right-hand photograph of each of these stereo-pairs is shown in Figure 25 (retort 3) and Figure 26 (retort 7). Surface detail can easily be seen over the whole extent of the flaking zone. The left-hand photograph of each pair was unfortunately less clear than that taken from the right, probably because of light from the flash bulb being reflected into the camera lens in the left-hand position.

Photogrammetric profile plots for retort 3 showed a maximum depth of flaking of about ¼ in. In the flaked band, the left-hand side (material A) appeared in stereo view to be very slightly less deeply flaked than the right-hand side (material B). The most useful function of the photogrammetric measurements, however, was in locating the flaking zone and measuring its extent. In retort 3, flaking started in the top silica course immediately under the sliding joint (this can in fact be ascertained by inspecting the brick joints in the photograph) and extended downwards for 28 to 30 in., terminating quite sharply at this level. This means that the flaking zone stopped at least 6 in. above the lower limit of the upper panels (materials A and B). The lower panels, containing materials C and D, were entirely unaffected, and it can be concluded from the position of the lower limit of flaking that the apparent immunity of C and D is due not to their superior resistance but to their being completely clear of the flaking zone in this face.

In retort 7, flaking again started immediately under the sliding joint and covered the whole of the upper panels. It stopped abruptly on the right-hand side 2 or 3 in. above the junction of the upper and lower panels, but on the left-hand side a light surface roughening could be seen extending nearly to the bottom of the lower panel. This roughening is not evident in Figure 26, but it could be seen clearly on the enlarged photographs, particularly in the stereoscope. Its position corresponds with that of material E, the material on the right being D. Profile plots through the flaked zone,

FIGURE 25.—*Flaked Zone of Retort* 3 (*Works* 3).

FIGURE 26.—*Flaked Zone of Retort* 7 (*Works* 3).

together with "hill-and-valley" measurements, indicated a maximum depth of flaking of about 0·4 in. There was no measureable difference between the two upper panels (materials B and C).

These photographic observations have provided little data by means of which the materials can be compared. It is only possible to say that E is worse than D, and presumably (judging from the pattern of flaking in the two retorts) worse than C, also. There is a small difference between A and B, in favour of A. It is unfortunate that D and E do not occur together as top panels on any visible face ; this combination occurs only on one of the platform-side faces, which can hardly be seen at all in these retorts. Material D forms the top panel in one visible face alongside A, and both observers placed it first in their orders of merit in the (unsatisfactory) visual inspection. This face was not photographed.

The inspection at this Works has provided rather doubtful confirmation of the superiority of material D and of the position of E at or near the bottom of the order of merit.

Two of the retorts in this setting contain a sixth trial material, F, which is similar to material C in porosity and permeability, but is made from a native rock. Its properties were described in the last Report. Panels of this material occupy diagonally-opposite positions in the four-panel trial areas, together with material C in two faces, and with A in the other two. The two visible faces were inspected visually, but neither observer was prepared to express an opinion regarding the relative degrees of flaking of the panels. These faces will be photographed at the earliest opportunity.

(*b*) *Effect of Iron Spots*

(*i*) *Continuous Vertical Retorts*

An opportunity to examine a cold continuous vertical retort embodying artificially produced iron spots has occurred recently. This upwardly heated retort has carbonized Yorkshire coals (singles and doubles) of swelling numbers 4½ to 7 since November, 1956, and is now about to have an intermediate repair before operating for a further three years. Operating temperatures have been controlled at 1,350°C, and scurfing by the downward method has been carried out at intervals not exceeding 35 days.

Bricks containing iron spots on both faces were built in on one long wall and one end wall from courses 30 to 70 inclusive. In addition, on the opposite long wall three black silica panels were incorporated at courses 20, 40 and 65. Only visual inspection was possible at this stage, but it was possible to draw certain conclusions from this examination. In the flaking zone (courses 55 to 70), iron spots had flaked along with the remainder of the face. The maximum amount of flaking was about 1 in., and in this area no sign of the iron spots remained. Above and below the position of greatest flaking, iron stains were left on the faces of the flaked bricks. On the opposite wall, the black silica (containing 4 per cent added iron oxide) had flaked to exactly the same degree as the normal silica surrounding it.

Between the flaking zone and the erosion zone (courses 35 to 55), iron spots had lost some of their colour, but were otherwise unaffected. The black silica panel at course 40 was likewise in perfect condition.

In the erosion zone, iron spots had lost colour and the cavities had enlarged from $\frac{1}{8}$ in. diameter to an inverted pear-shaped crater of ½ in. length and ¼ in. maximum width. There was no appreciable increase in the depth of the cavities. It is thought that these spots will now have reached a composition identical with that of the remaining brickwork and that no further enlargement will occur. It proved impossible to identify the black silica panel at course 20, indicating that the normal silica bricks surrounding it had reacted with ash and slag to such an extent as to have a colour identical with the black panel.

A more detailed report of the performance of these bricks will be made after the retorts have reached the end of their useful life, but it seems fair to say that the presence of iron spots and actual craters has had no untoward effect in a period of three years. Iron stains, as distinct from cratered spots, were seen between courses 35 and 55 and were not affected in any way except for slight bleaching in some cases.

Reports from engineers where other iron spot trials are proceeding indicate that no effects on the performance of the retorts have been noted at any Works.

During the inspections of the flaking-trial retorts, adjacent retorts containing bricks with artificial iron spots were also examined by members of the Research Association staff. They were unable to locate the spots and could see no unusual features on the walls that could conceivably be associated with iron spots. It was their impression that little useful information on these trials will come from visual inspections of the hot retorts.

(*ii*) *Intermittent Vertical Chambers*

A report from the Area Gas Board where this trial is in progress states that there are no obvious differences between spotted and non-spotted chambers. These chambers will be available for inspection in April, 1961.

(*iii*) *Horizontal Retorts*

When, in 1956, a bed of six horizontal retorts was reset in the North Eastern area, silica segments containing iron stains were specially selected and built in to the top left-hand retort. The iron stains were adventitious, that is to say, they were not artificially produced by ball-bearings and did not include craters. The positions of 129 stains were marked on a chart, which shows that there were roughly 12 stains per ring of 10 segments.

The retorts were brought to working temperature in 37 days and have since worked for 1,400 days, carbonizing Yorkshire coals. The combustion chamber temperature was approximately 1,350°C. Retorts were discharged each 12 hr and scurfed at intervals of approximately two months.

The staff report that they have been unable to discern any difference in the operating characteristics of this retort compared with the other five.

An inspection of the cold retort has recently been made. The working faces of all segments were found to be smooth, with no evidence of loss. No evidence of iron stains could be detected except in the two rings nearest to the discharge end, where some stains remained visible.

Whether the iron compounds have migrated into the remaining brickwork or reacted with volatile compounds in the gas to produce almost white compounds is not known.

It is safe to say that, under the conditions prevailing at this Works, iron stains are in no way deleterious.

(2) THE ACTIVATION OF COKE

Enquiries have been received from a number of sources concerning the possible harmful effects on refractories of alkali added to the coal in carbonizing processes in order to activate the coke. It is understood that this process may be put into practice in various installations, including horizontal retorts and coke ovens. While it was safe to say that no benefit to the refractories could ensue, it is impossible to say how much damage might be done. Reporting on an experiment concerning the activation of coke in continuous vertical retorts, which had operated for 3½ years before the process

was started, A. T. Green* concluded that inspection, measurement and analyses all indicated more erosion on retorts where activation was carried out than on adjacent retorts carbonizing coal with no additives. Deterioration was greatest in the corners in the lower silica courses. However, considering the total life obtained from the retorts, the final condition of the brickwork was thought to be reasonable. He also pointed out that temperatures had been somewhat lower than might be considered normal practice.

The action of the sodium carbonate is not fully understood, though there is no doubt that it has a decided influence on the appearance of the coke removed from coke ovens. Instead of long "fingers" of coke, the discharge from "activated" ovens is distinctly rounded and may be more porous. A considerable part of the added alkali is "fixed" on the coke in some form of chemical compound. Alkalies are found in considerable quantities in the carbon lining of blast furnaces, and Dr. R. B. Snow, of United States Steel Corporation, has recently informed the Association that he has identified compounds of sodium and carbon of the type Na_xC_y where y is probably a large number, in carbon blocks removed from blast furnaces.

The Research Association is at present conducting a small scale investigation on the amount of alkali absorbed by silica brickwork at temperatures of about 950° to 1,000°C. Coal supplied by the East Midlands Gas Board has been sprayed with water to give about 10 per cent surface moisture content and then dusted and mixed with sufficient soda ash to give a sodium carbonate addition of 0·75 per cent.

Laboratory work on the impregnation of silica bricks with carbon has been conducted over the past two years in a steel tube 38 in. high and of 8½ in. diameter. This has been provided with a silica bottom and lined with silica bricks to a height of 27 in. for the trials on alkali pick-up. After bringing the "retort" up to temperature, about 20 lb of treated coal has been charged and carbonized for 4 to 5 hr. After cooling, the charge was removed, totally crushed and sampled for analysis. At the same time, part of the bottom was removed for examination and replaced by fresh brick, and one side panel out of the 24 used was also replaced. A slice about ¼ in. thick was removed from these brick faces, ground and analysed. This procedure has been carried out four times. Further trials will be made during the next few months with samples examined after longer carbonizing periods.

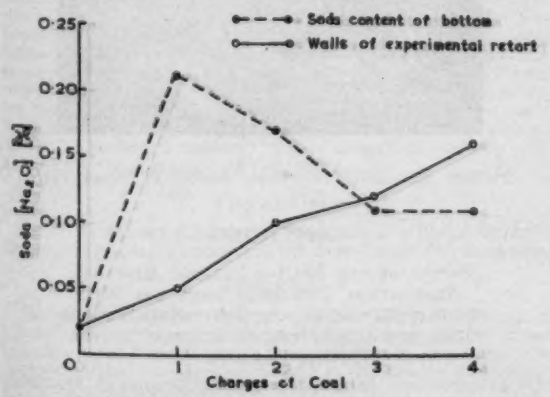


FIGURE 27.—*Soda Content of Brick Surface in Laboratory Retort Making Activated Coke.*

* Green, A. T. *Trans. Inst. Gas Eng.*, 91, 1941-42, 210.

The results so far obtained are shown in Figure 27. It will be observed that the results for the bottom of the retort appear to indicate that the alkali content is practically constant at 0·11 per cent, at least after four cycles. The high values obtained after the first and second cycles might indicate imperfect mixing of the carbonate with the coal, since sample 4 has been subjected to four cycles and has absorbed only 0·11 per cent soda.

The side bricks, however, appear to be continuing to react with alkali, and it is with a view to determining when equilibrium is established that this work is to continue.

The soda concentration in the coke was found, by flame photometric determination, to be 0·51 per cent. This corresponds to 0·87 per cent sodium carbonate in the coke. Bearing in mind that the coke weighs roughly three-quarters of the coal, it will be observed that a loss of alkali of about 0·13 per cent has occurred. Analysis of the coal ash shows that there is a considerable discrepancy between the alkali content of the coal, the added alkali and the alkali found in the coke and the bricks. Laboratory experiments are about to be initiated where conditions will be closely controlled in an effort to obtain an "alkali balance".

To what extent it is possible to tolerate the addition of alkali to silica bricks is not known, since it will vary with the type of retort, the flue system and the working temperature. It is considered, however, that clay-bonded siliceous retort material, because of its lower tolerance to alkali addition, would be unsuitable for use in retort settings in which this process is to be operated.

(3) The Measurement of Tensile Strength of Refractories at High Temperatures

Of the methods available for the determination of tensile strength, the so-called "disc test" is, perhaps, the most suitable for use at elevated temperatures. It depends on the fact that a disc compressed between knife-edges fails in tension by cracking in the direction of the applied pressure.

The apparatus used is shown in Figure 28 and consists essentially of a small electrically heated furnace in which discs of refractory can be compressed until failure occurs. The loading system is made from heavy steel bars with ball bearings at all moving points to reduce friction, and with steel guides for the thrust rod.

Experiments on disc size appear to indicate that 1 in. diameter is most convenient. The thickness of the disc may well be very important in that it may be essential to have the thickness of the disc greater than the size of individual brick grains.

Work on the measurement of the tensile strength so far indicates a tendency for the strength to decrease with increasing temperature, but the experimental procedure has yet to be perfected. Material D of the field trials on flaking has been tested by this method and the values obtained are shown in Figure 29.

(Figure 30 shows a silica brick specimen broken in the apparatus.)

The tensile strength of material D—a silica brick—would appear to decrease to about half of its room temperature value when the temperature is between 900° and 1,200°C. Measurements of the moduli of bricks mentioned elsewhere in this Report indicate that some silica bricks pass through a minimum at about 200°C, and future measurements of tensile strength will include determinations at this temperature.

(4) A Study of Spalling

The stresses in a body subjected to thermal shock can only be calculated if certain simplifying assumptions are made

regarding the shape assumed by the end planes. It is commonly assumed that the body is infinite or semi-infinite in extent and that no element is displaced from its original position, so that the thermal expansion of the material is completely

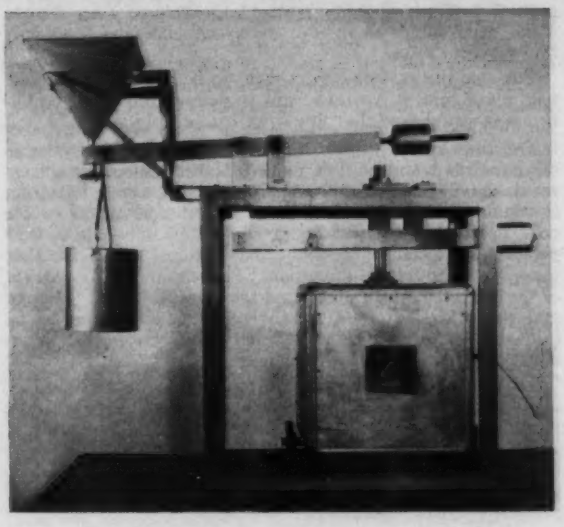


FIGURE 28.—*Tensile Strength Apparatus.*

suppressed and may be regarded as a strain. Stresses in a finite body can be calculated by assuming that the originally plane ends of the body remain plane in the stressed state.

Neither of these assumptions can explain why a large body spalls more readily than a small one, for the stresses calculated in each case are independent of the body's size. The "size effect" and the characteristic patterns of cracking given by bodies of different shape,[11] can best be explained by assuming that the stresses set up in a body depend on the distortion of its ends, the degree of distortion depending on the size and shape.

The movements of the ends of bricks of differing sizes and shapes, heated on one face at various rates of heating, are being measured by means of dial gauges. The curvature of the end faces indicated by the gauges is compared with the theoretical shape calculated from the thermal expansion of the material and the temperature distribution measured under the same conditions of heating. Results so far obtained support the view that the shape of the ends of the bricks departs appreciably from the plane form and that the stress produced at a given rate of heating increases with the dimensions of the heated face.

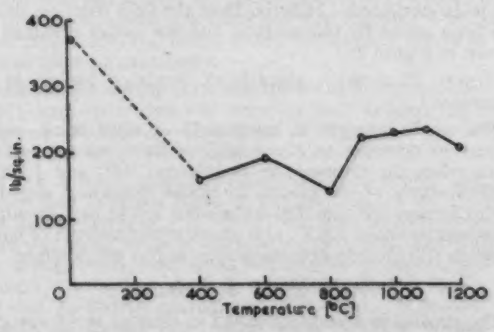


FIGURE 29.—*Tensile Strength of Material D (Silica Brick).*

(5) A STUDY OF THE PROPERTIES AND BEHAVIOUR OF MOULDABLE AND CASTABLE REFRACTORIES

An investigation of the properties of mouldable and castable refractories has been proceeding for two or three years, with particular reference to their performance in marine boilers. More recently, the study has been widened to include the application of mouldables and castables in the iron and steel industries. Since these materials are now coming increasingly into use in the Gas Industry, the Joint Refractories Research Committee has requested that it should be kept informed of the progress of these investigations, and reports will accordingly be submitted from time to time.

The properties examined so far are chemical analysis, grading, shrinkage in drying and after firing at various temperatures, porosity and strength after these firings, resistance to thermal shock, and thermal conductivity. Since there are no standard tests in this country for mouldables and castables, a Working Group of the Research Association's Testing Committee has been set up to study methods of testing.

Both mouldable and castable refractories have been found to be much more resistant than normal refractories to thermal shock, when tested in the unfired state. If either type of material is prefired before testing, this exceptional resistance reverts to that of normal-fired bricks.

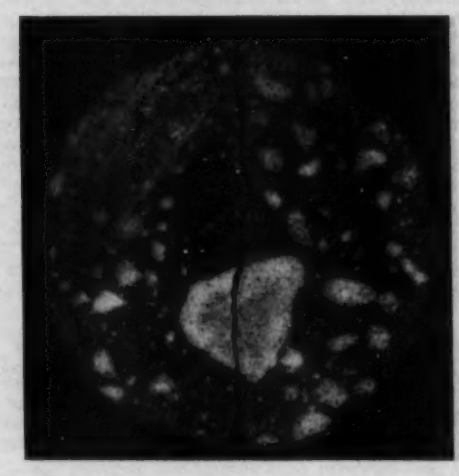


FIGURE 30.—*Silica Test Piece Broken in Tensile Test.*

APPENDIX

PAPERS OF THE BRITISH CERAMIC RESEARCH ASSOCIATION, PUBLISHED SINCE THE 50TH ANNUAL REPORT OF THE JOINT REFRACTORIES RESEARCH COMMITTEE, OF INTEREST TO THE GAS INDUSTRY

(1) Recommended Methods for the Application of Mouldable and Castable Refractories. A Report of the Marine Boiler Refractories Committee of the British Ceramic Research Association and the British Shipbuilding Research Association. (*Special Publication* 20.)

(2) The Spectrophotometric Determination of Silica in Some Alumino-silicates (<40 per cent Al_2O_3). A Tentative

Method, by H. Bennett, R. P. Eardley, and W. G. Hawley. (*Special Publication* 22.)

(3) Furnace Periscope and Flow Visualization, by P. L. Scorey, W. H. Holmes and E. Rowden. (*Research Paper* 437.)

(4) The Physical Properties of Ceramic Bodies at High Temperatures. Part I—The Measurement of Modulus of Elasticity, by L. J. Davies and R. Brough. (*Research Paper* 444.)

(5) The Physical Properties of Ceramic Bodies at High Temperatures. Part II—The Measurement of Transverse Strength, by L. J. Davies and R. Brough. (*Research Paper* 445.)

(6) Relations between Properties and Structure, by S. N. Ruddlesden. (*Research Paper* 451.)

(7) Heat Flow through Kiln Structure. Part II—Town Gas-fired Open-flame Kiln for Firing Earthenware Glost, by D. L. Salt and W. H. Holmes. (*Research Paper* 464.)

(8) The A. T. Green Book. (A Volume comprising 26 original papers on research in the ceramic industry written by the staff of the Research Association as a tribute to Dr. A. T. Green, the retiring Director of Research.)

INTRODUCTION, PRESENTATION, DISCUSSION AND REPLY

Introduction

Dr. A. L. Roberts (Livesey Professor, University of Leeds; Chairman, Joint Refractories Research Committee) introduced the Report, and in the course of his remarks said :—

My duty and privilege is formally to introduce the 51st Report of the Joint Refractories Research Committee. During the year, there were two changes of membership. We lost a valued member by the untimely death of Mr. Tom Simpson, of the North-Western Board; in addition, Mr. Colin Stein found himself unable to continue on the Committee, and in his place we welcome Mr. Whiteley as a representative of the British Ceramic Research Association.

Even the new format of the Report cannot disguise the fact that again it is a bumper edition dealing with a wide variety of topics mostly of direct interest to the gas industry, with some perhaps of indirect interest, but none the less important. Dr. Astbury will be presenting the Report in some detail, but perhaps I may draw attention to one or two matters.

A new factor has appeared in the attack on the flaking problem, namely, the critical strain, i.e., the amount of deformation the brick will withstand before it breaks. Dr. Astbury and his colleagues are properly cautious in not claiming too much of this factor at this stage, but it must be significant that this property seems to place the material undergoing flaking trials in the field neatly in the order of their measured resistance to flaking. We shall look forward eagerly to the continued study of this factor.

Other sections of the Report deal with studies on the burning of scurf, the evils that may beset refractories in oil gas plant—in this section we are indebted to Mr. J. H. Wylde, a member of our Committee, for an account of valuable experiments carried out by the North Thames Gas Board—and with the highly important question of the testing of refractory materials. In this last section, one will have seen the ingenious use of electrical methods for pinpointing the fall of pyrometric cones and so expressing their indications in terms of temperature. Unexpected snags in apparently simple testing procedures are well illustrated by the extraordinary way in which cold crushing strengths of bricks may be affected by the packing material used. I hope it will be agreed that the year's work has brought further clarification of the problems of refractories in service in the gas industry. I have pleasure in formally submitting the 51st Report of the Committee.

Presentation

Dr. N. F. Astbury (Director of Research, The British Ceramic Research Association) presented the 51st Report for discussion.

Discussion

Mr. S. J. F. Beale (Derbyshire Silica Firebrick Company, Limited) :—The Report presented is of particular interest to gas engineers since three of the sections are directly concerned with progress in the investigations related to the deterioration of refractories in the flaking zone of vertical retorts.

There appears to be at last a " break-through ", to use a topical term, in the search for some measurable property of refractory materials, at operating temperatures, which bear a direct relationship with the severity of flaking. Though a considerable amount of investigation and correlation still remain to be done, the work on the critical strain represents a notable advance by the staff of The British Ceramic Research Association. Manufacturers and users of refractories will be very interested in the future development of this particular facet of the flaking problem. To my knowledge, this problem of flaking has been receiving attention for at least 30 years. It will be interesting to hear the results of further work done in the attempt to achieve a judicious balance between the crystalline and glassy components of bricks. Would it be possible to do some work on bricks similar to those shown in the table on p. 344.

On p. 345, under " Conclusion ", it is suggested that, in the flaking zone, the edges of retort bricks could be chamfered back about $\frac{1}{4}$ in. and the joints raked back to relieve compressive stresses. One wonders what would be the effect on descending charges, especially if very fine coal got into the space thus provided, and whether interference with the travel of the charge would occur. It would be interesting to have the views of carbonizing engineers and retort designers on this point.

The use of photogrammetry, even with its limitations, as an additional tool is one that it is hoped will be developed further in accuracy and use. The B.C.R.A. is to be congratulated on introducing this method, and it is hoped that it will be rewarded with success, to its reasonable satisfaction.

Use of the profile gauge and photogrammetry are complementary to each other, and will lead to more speedy assessment of the flaking tendency in the properties of the bricks.

With regard to the rate of burning scurf, although the mechanism of this operation when using steam is not clear, the work done on the use of large and small quantities of steam is interesting. When using large quantities of steam, it is obviously necessary to have the retorts at sufficiently high temperatures, as mentioned in the Report. I have seen figures, obtained at a gas works in 1929, showing that the use of large quantities of steam reduced scurfing time considerably. It seems that this method could be used to advantage at gas works where the operations can be carried out under closely controlled conditions. Think of the advantage under peak output conditions !

The use of even small quantities of steam will reduce the temperature of the scurf-refractory interface. The control of this temperature is most important, and I believe that much damage is done to the refractory when this temperature is allowed to get too high, which I suspect occurs at gas works that do not have good technical supervision at night.

With regard to oil gas plants, it is evident that, with the present knowledge of refractories, the two top courses in the steam regenerator, when using 950 s oil, should be of high temperature alloy metal instead of refractories.

In the testing of refractory materials, the problem of obtaining similar results from different laboratories is a very difficult one. The differences are small, but of great importance. However, progress is being made and one can only wish success to those working on this problem.

On the question of retort brick iron spots, it is interesting to read that what is termed " black silica ", which is silica to which 4 per cent of iron has been added, has shown no greater flaking or deterioration than ordinary silica ; also, that actual cavities in the bricks, due to iron, had no untoward effect on the refractory after a period of three years' use.

I hope that those responsible for the building and operation of carbonizing plants will read, digest and also remember what has been reported. I hope, too, that they will accept the implications of the accumulated evidence and give effect to it by the revision of their present standards of rejection of iron-spotted refractory materials.

One point is bothering many members. The Institution's Reports and Papers arrive so late that it is quite impossible to absorb the contents between the time of receipt and the Meetings concerned.

I have no doubt that the Institution has to urge Authors and Committees to hurry up so that the papers can be sent to the printers. I can only suggest that the deadline should be set earlier, and, what is even more important, maintained in spite of any opposition.

Should what I have said concerning the refractories Report sound as though I have written it in a rush, that is so. I wish there had been more time for its compilation.

The President :—On the question of the late arrival of preprints, I should like to assure Mr. Beale that the staff of the Institution has a great problem on its hands in ensuring that the papers come in in time to have them printed and distributed. In one or two cases, whatever may be the dead-line, they do not come in until perhaps a day or two within the dead-line. We are striving always to make sure that the papers are distributed in time for them to be read before the Meetings, and we shall continue to give this matter our attention.

Mr. A. F. Cottrell (London) :—I propose to confine my remarks to the almost perennial subject of flaking in continuous vertical retorts, which is (although it would, perhaps, be better to say " was ") of primary importance to the gas engineer. I should like to congratulate the Committee and the investigators on their efforts during the year to provide still more valuable information on the properties and behaviour of the refractories used in the gas industry.

As Mr. Beale has said, flaking once more gets the lion's share of the Report, but, unfortunately, it still offers no solution to the problem, although it may get us a little further forward in its study.

It would be dangerous to comment on the new theory of critical strain, because it has been developed on rather a thin foundation, the results of merely one set of reliable examinations. Many theories have been put forward and discarded in the 30 years or so that this investigation has been in progress, and it may be that this one will ultimately suffer the same fate. But, on the other hand, it has as its basis some more or less agreed data—the setting up in the silica brick faces of certain stresses caused by the different behaviour of the brick itself and the layer of scurf. Where it differs from previous thought is that porosity or permeability of the bricks is no longer considered to be significant, which is in line with observations made by others who have been studying low-porosity materials, and tends to confirm that such bricks under average English conditions have little, if any, advantages over normal silica. This approach will, therefore, be welcomed, and, whilst it is obviously too early to say more about the matter, we shall all wish the investigators " good luck " in their further work along these lines.

Nevertheless, I fear that flaking will be with us for a long time yet, and it is pleasing to know, therefore, that it is no longer such a serious practical problem as it was when these investigations were first instigated.

For the sake of the younger engineers, it should be made clear that at that time there were a large number of downwardly heated retort installations that flaked so deeply in the 2 to 3 ft of silica ust below the top firebrick that repairs were necessary every 2½ to 3 years. Today, however, there are less than 20 of these installations in England, the rest being upwardly or lambently heated, repairs to which are rarely required more frequently than every six or seven years, so that there has been a considerable improvement in this matter. This does not mean, of course, that the research work is not necessary, but that concurrently with these investigations, and, in fact, ahead of them, the retort builders, the brick makers and the refractory users have got together and, by means of changes in design, better and more uniform quality of bricks and more attention to plant operation, have succeeded in doubling and in some cases trebling the working periods between repairs ; this is not, I suggest, an insignificant achievement.

Gas-making methods are changing, however, even in continuous vertical retorts, and it may well be that these changes will affect flaking in one way or another. The two changes that I have in mind are the production of premium fuel by adopting higher throughputs and the injection of light distillate. It is my guess that the premium-fuel working will deal more kindly with the silica, and the light distillate less kindly, and it behoves works engineers and the Refractories Research Committee to watch these innovations very carefully.

I am bound to say that in my opinion the only certain way to measure the depth of flaking is to cool the retorts and go inside. Admittedly, this means slow progress, which we are used to, but it will ensure that correct information is obtained.

As the Authors of the Report so rightly mention, one of the main difficulties in obtaining this information during working is the discomfort suffered by the investigators, who have to stand over open retorts. " Discomfort ", in fact, is a gross understatement, as many members will appreciate, and it would be surprising if such conditions did not adversely affect accuracy and perhaps enthusiasm.

The profile gauge obviously has limitations and could hardly be used where there is a deep belt of flaking ; thus its use is limited to narrow bands in downwardly heated retorts, which we know are no longer being built. Incidentally, this prompts me to ask why the Committee persists in examining this type of retort, and, having done so, why some of the test panels were put below the level of the normal scurfing zone? Admittedly, the flaking of these retorts commences early in their life and proceeds more quickly, but is it not possible and, indeed, likely that the tenacity of the scurf formed as the result of heating downwardly sets up different strains to that formed by the more popular form of heating upwardly, and could this not upset the common factor now being sought to substantiate the critical strain theory ?

The development of photogrammetric methods is certainly ingenious and may well prove useful in the research work, but, from the purely practical aspect, it is doubtful whether either of these methods is suitable or necessary for determining the repair programme.

Finally, I am wondering whether the time is not ripe for the Committee to state exactly where this investigation stands. Whilst all this painstaking work has been published in the *Transactions* of The Institution of Gas Engineers and in separate *Research Communications*, I cannot remember any up-to-the-minute summary. Could there not be published as a single statement, for the benefit of the younger engineers, the results of this work to date? Young men who are retort house engineers know much about the incidence of flaking, but few of them have access to all these various publications, and would, I feel sure, value something of the kind suggested for easy reference.

Dr. E. Johnson (Leicester) :—Mr. Sabiston, in his section on oil gas plant, has adequately demonstrated the mechanism of the fracture of the top course of refractories. He has shown that in fact this is purely a thermal effect. It is rather interesting to see Figure 17, which, in my opinion, might have been more impressive had it been shown " exploded ", as it were. This is a block that was taken out of a plant after it had been in operation for three days only, and it is typical of the full course. There is a horizontal fracture starting at the point where the vertical surface begins to curve, and extending the full length of the block, and there are vertical fractures from the top surface of the block down to the horizontal plane, and extending further down.

When one takes the pieces away, there is no blackening of the inside surface. Certain people felt that it was the carbon that was helping to create this effect. In the first stages, I am convinced, it is a purely thermal effect, and only when the cracks have been formed does the oil penetrate ; examinations after three weeks show quite definite carbon penetration.

Mr. Sabiston has said that this problem has been reasonably overcome by the use of special alloy blocks. There is the discussion whether there should indeed be one course or two courses of these blocks. My own feeling is that there should be two. Mr. Sabiston has said that the second layer of refractories in a steam regenerator very often is in a condition to continue, but I have seen plants where the second course of checkers has been badly affected and, indeed, the majority have had to be replaced.

Mr. Sabiston has said that in general the refractories within the catalyst vessel are satisfactory. In general, I think I can agree with him, but I should like to bring to his attention the fact that on one occasion we did have a failure of what is known as a J-block, i.e., an intermediate support that rests on the arches and supports the tiles on which the catalyst is laid. There was only one block in that particular plant. On another plant, when it was opened up, it was found that these blocks, or many of them, were very badly cracked and had to be replaced ; indeed, the arches on which the blocks were rested had to be replaced.

Written Reply

The **Authors**, in reply, wrote :—The Authors wish to express their thanks to those who have taken part in the discussion and have shown so much interest in their work.

Their feelings on the new property of critical strain and its relation to flaking are exactly reflected by Mr. Beale and Mr. Cottrell's views, taken in combination ; that is to say, they are moderately elated at having found a property that seems to have some bearing on flaking, but are acutely aware that others in the past have been similarly elated over theories that are heard of no more. The curves relating critical strain with temperature themselves suggest a note of caution, for the differences between the Authors' trial silica materials are clearly becoming smaller as the temperature rises. Measurements of the critical strain up to 1,200°C, which the Authors now have in hand, should show the effect of high brick-face temperatures in the flaking zone.

The attempt to influence the critical strain of silica bricks by the addition of various materials to the brick mixture is at too early a stage to enable the Authors even to speculate on its possible success. They have to bear firmly in mind one primary requirement, which is that the final product of this " tinkering " with the brick mix must still be a silica brick, with its refractory properties unimpaired. This consideration limits very severely the range of eligible materials, and, in addition, the proportion of these materials that can be added may be limited by their cost. The Authors' impression at the moment is that such improvements in critical strain as may be induced by foreign additions will not be spectacular.

Like Mr. Beale, the Authors would be interested to have the view of carbonizing engineers and retort designers on the suggestion that in the flaking zone the edges of retort bricks should be chamfered back to relieve compressive stresses. The possible effect of this modification on the travel of the charge would of course be a major consideration in deciding whether it could safely be tried in a retort.

The Authors' views on the two proposed methods of assessing the degree of flaking, i.e., photogrammetry and the profile gauge, are once again a combination of the views of Mr. Beale and Mr. Cottrell. The Authors are aware of the potentialities of both methods, and of their limitations.

It is to be hoped that carbonizing engineers will take note of Mr. Beale's remarks on the possible advantages of scurfing with large quantities of steam. Any measure that helps to check the large rise of temperature due to the too rapid burning of scurf, must be beneficial to the refractories.

In the past three or four years, a good deal of evidence has been accumulated in favour of the view that iron spots in silica bricks have no harmful effect on the behaviour of the bricks in carbonizing plant. It is to be presumed that this evidence will in due course be brought to the notice of those responsible for drafting specifications on refractories for the carbonizing industries.

The Authors are trying to adopt Mr. Cottrell's cheerful view of the flaking problem on the grounds of its diminution with the years. Their view is possibly coloured by the presence of a gas works only 2 miles from their laboratories, where the retorts are downwardly heated and duly call for repairs every 2½ to 3 years. The thought that there are as many as 20 such works in the country, and that flaking in other types of retort, although less severe, is not negligible, also stands in the way of dismissing the problem as being of minor importance.

The present Authors were, unfortunately, not present at the meeting at which the design of the flaking trials was decided, but they can assure Mr. Cottrell that the contractors were represented in the group charged with this task. The group included also representatives of the Joint Committee and the Research Association. This group selected the types of retort in which the trials were to take place, presumably with the contractors' approval. The actual location of the bricks in the retort, with respect to the flaking zone, was similarly agreed in the presence of representatives of the contractors. It is unfortunate that the trial panels have not always coincided with the flaking zone, but the Authors have no wish to join in the unpleasant task of apportioning the blame for these errors.

The Committee is aware that some retorts are now being operated under conditions for which they were not expressly designed, i.e., for the manufacture of premium fuel, and for the gasification of light distillate. While there is no report of the premium-fuel process having produced any harmful effect on the refractories, there have been several disquieting indications that the very heavy scurf deposition following the injection of light distillate may induce or aggravate flaking. The Joint Committee and the Research Association are keeping a close watch on these new developments.

In calling for an up-to-date review of the investigation on flaking, Mr. Cottrell may have overlooked Mr. Laming's review, published in 1958, in the 49th Report of the Joint Refractories Research Committee.* This paper summarized the position up to the date of its publication, and it seems a little early to undertake another review of the same subject.

The Authors are indebted to Dr. Johnson for his observations on oil-gas plant, and for his reminder that the top checkers are not invariably the only source of trouble. They are interested to hear that he advocates the replacement of the top two checker courses with alloy blocks. The replacement of the second course may be an expensive insurance against possible trouble, but this point can only be settled by experience.

* Gas Council Res. Comm. GC55.

New Ordinary Members of Council

In connexion with the 98th Annual General Meeting of the Institution, and in accordance with By-Law 50, four corporate members were elected to be Ordinary Members of Council for the years 1961-62 to 1963-64. (See *Journal*, Vol. 1, No. 6, p. 430.)

Short biographical notes relating to the new Ordinary Members of Council are given below.

D. Beavis

David Beavis was born in Glasgow on 12th December, 1913, and educated at Whitehill Secondary School, where he became Junior Dux, and at the Royal College of Science and Technology, Glasgow, where he was a Prizewinner in Engineering Design and Heat Engines. He was a pupil in the Glasgow Corporation Gas Department from 1928 to 1933, when he was appointed Junior Technical (Engineering) Assistant at Provan Works. In 1935, he became Assistant Engineer and Manager to the Helensburgh Gas Department ; in 1941, Assistant Engineer to the Cambridge University and Town Gas Light Company ; and, in 1947, Deputy Engineer and Manager to the Edinburgh Corporation Gas Department. Upon nationalization of the gas industry, Mr. Beavis was, in 1949, appointed to be Divisional Controller of The Scottish Gas Board's Edinburgh Division. In 1957, he became General Manager of the Board's Edinburgh and South Eastern Division, and in 1960 was made Area Manager, The Scottish Gas Board. Mr. Beavis, who is an Associate Member of The Institution of Mechanical Engineers, was elected an Associate Member of The Institution of Gas Engineers in 1941, and transferred to full Membership in 1946. He previously served as an Ordinary Member of Council from 1952-53 to 1954-55. In 1945, Mr. Beavis was awarded the Institution's Diploma in Gas Engineering (Manufacture) with distinction, and the Charles Hunt Memorial Medal. He was awarded the Institution's H. E. Jones London Medal for 1958 for his paper, " Work Study : Three Years' progress at Edinburgh ", which he had presented to the 95th Annual General Meeting of the Institution, in London, on 15th May, 1958.

S. K. Hawthorn

Sidney Kenneth Hawthorn was born on 19th December, 1901, and educated at Waverley Road Secondary School, Birmingham, where he matriculated and afterwards won a University scholarship which he could not take up ; he studied gas engineering subjects at Birmingham Technical School. In 1918, he joined the City of Birmingham Gas Department as a junior chemist under Dr. E. W. Smith. After drawing-office and works training he was, in 1936, appointed Engineer of the Department's Windsor Street Works, at that time the second largest gas works in Britain. In 1946, he became Deputy Chief Engineer of the Birmingham Gas Department, and Chief Engineer two years later. Upon nationalization of the industry, he was appointed, in 1949, Divisional Engineer of the West Midlands Gas Board's Birmingham Division. Mr. Hawthorn is a Member of The Institution of Civil Engineers and also of The Institute of Fuel. He was elected a Member of The Institution of Gas Engineers in 1930. In 1933-34, he was President of the Midland Junior Gas Association ; and Chairman of the Midland Section of the Institution in 1960-61. An Institution first-class Diploma in Gas Engineering was awarded to Mr. Hawthorn in 1929, and he is the only holder of the Institution's Gold, Silver and Bronze Medals. He received the Gold Medal for 1953 for his paper, " Some Special Features of the New Swan Village Gas Works ", presented to the Institution's 90th Annual General Meeting on 19th May, 1953 ; the Silver Medal for 1950 for his paper, " Making the Best Use of Existing Gas-making Plant and Planning Extensions with Maximum Economy ", presented to the Midland Association of Gas Engineers and Managers on 16th February, 1950, and the Bronze Medal for 1930 for his paper, " Oxide Purification ", presented to the Midland Junior Gas Association on 13th March, 1930. Mr. Hawthorn has been a member of Council since 1957, as an Ordinary Member from 1957-58 to 1959-60 and as a District Member in 1960-61.

C. D. Shann

Charles Douglas Shann, M.A., was born at York on 4th March, 1907, and educated at St. Peters School, York ; Oundle School, and Caius College, Cambridge, where he obtained an honours degree in the Mechanical Sciences Tripos. He joined the staff of the Gas Light and Coke Company, in 1928, as an Assistant Engineer at Southall Works, and transferred to the Distribution Department in 1930, being appointed Assistant Distributing Engineer in 1938. During the early part of the Second World War, Mr. Shann's duties included responsibility for the G.L.C.C. Civil Defence organization, created to maintain the distribution of gas following damage to plant by enemy action. He also commanded three Home Guard engineer companies. In 1943, he joined the staff of the Directorate of Gas and Heat Supplies, Ministry of Supply, as an Assistant Director, planning gas distribution plant requirements for enemy-occupied countries on their liberation, and also made fuel surveys at Ministry factories. He resumed duties with the G.L.C.C. in 1945, and, upon nationalization of the gas industry, was appointed Assistant Distributing Engineer of the North Thames Gas Board. He was awarded the Society of British Gas Industries Silver Medal and the Milbourne Prize for a paper to the London and Southern Junior Gas Association in 1947, and became President of that Association in 1952-53. Early in 1954, he was given leave by the North Thames Gas Board to assist the William Press organization in preparing schemes for the distribution and utilization of natural gas in Karachi and other cities in West Pakistan, and

became so interested in the development of the entirely new gas industry in that country that, later in the year, he joined William Press and has continued to be concerned with the gas industry of Pakistan, particularly in Karachi, ever since. He has seen gas consumption there rise from zero in 1954 to rather more than 200 mill. therms in 1960. He has also been concerned with projects for the utilization of natural gas in several countries in the Middle East, and also in India and the West Indies. Mr. Shann makes frequent journeys overseas, and has now visited Karachi 14 times. He is a member of Council of The Society of British Gas Industries. Mr. Shann is a Member of The Institution of Civil Engineers, and a Member of The Institution of Gas Engineers since 1939. He served on The Institution of Gas Engineers Board of Examiners, and was Chairman of the Supply Panel in 1952-53. He is currently Gas Consultant to the William Press group of companies.

Guy Hamilton Fuidge, B.Sc., was born on 10th March, 1901, and educated at Taunton's School, Southampton, and at the Sir John Cass College of the University of London, where he graduated in Chemistry, Physics and Mathematics. He entered the Chemical Laboratory of the South Metropolitan Gas Company in 1919, as a chemist and research assistant dealing with problems of gas production and purification. In 1928, he became Senior Research Chemist. He was appointed Chief Physicist to the Company in 1948, which appointment was confirmed by the South Eastern Gas Board upon nationalization of the gas industry. Mr. Fuidge became Manager of the Central Laboratories of the Board in 1958. He is the author of numerous papers on coke, tar, and the combustion characteristics of town gas, and has collaborated in reports on corrosion problems in gas appliances. Mr. Fuidge has given valuable service on a number of important committees dealing with gas utilization, solid fuels, tar and other bituminous products, and the technical and utilization aspects of coke development, as well as to a number of panels of the British Standards Institution. He was awarded the Institution's Gold Medal for 1955, as joint author of a paper, " The Tolerance of Aerated-burner Appliances to Variations in the Combustion Characteristics of Town Gas ", presented to the 21st Autumn Research Meeting of the Institution on 22nd November, 1955.

Personal Notes

Appointments

(a) By Area Gas Boards :

SCOTTISH GAS BOARD

Edinburgh and South Eastern Division—
Divisional Manager : **J. E. Brandon**

NORTH THAMES GAS BOARD

Chief Service Manager : **R. P. Rhodes**

Central Division—
Group Engineer : **J. Cross, M.Sc.**
Projects Engineer : **W. J. Walters, B.Sc.**

Northern Division—
Commercial Assistant to Divisional Manager : **F. F. G. Clarke**

Beckton Works—
Deputy Station Engineer : **A. C. Nelson**
Senior Assistant Engineer : **D. R. Coote, B.Sc.**

Romford Works—
Assistant Engineer : **J. A. Ward, B.Sc.**

SOUTH EASTERN GAS BOARD

Sussex Division—
Divisional Distributing Engineer : **D. H. F. Burchell**

(b) General :

Mr. R. A. Bradfield (AM) has been appointed Sales Manager (Industrial and Commercial) to the Brisbane Gas Company Limited, Australia.

Mr. G. Dent (AM) has been appointed Assistant Lecturer in Mechanical Engineering at Southall Technical College. This appointment takes effect from 1st September, 1961.

Retirements

Mr. W. S. Hubbard (M) has retired from his position as Production Engineer, Mersey Group, North Western Gas Board.

G. E. Currier, Esq., O.B.E.

Members will be pleased to learn that Mr. G. E. Currier, O.B.E., Honorary Secretary of the Institution, who was taken ill on his way to attend the Institution's 98th Annual General Meeting in London, and was admitted to the Charing Cross Hospital, has made good progress towards recovery.

Mr. Currier returned to his home at Horsforth, Leeds, on 10th June, where he will continue his convalescence for the next few weeks.

Addresses Required

The Council would be grateful to receive the present addresses of the following members, last heard of in the places given in brackets :

Mr. W. G. Bignell (Eastbourne).
Mr. E. Clark (Bridlington).
Mr. S. W. Hayes (Braunton).
Mr. D. Helliwell (Halifax).
Mr. P. W. Hugh (Middlesbrough).
Mr. C. Kay (Cambridge).
Mr. N. P. Shepherd (London).
Mr. A. W. Somerville (Bury).
Mr. A. M. Steel (Gutersloh, Germany).
Mr. E. F. Surti (Birmingham).
Lt.-Col. T. C. Whimster (Ashford).

News from the Gas Industry Overseas

Deutscher Verein von Gas-und Wasserfachmännern

The Institution of Gas Engineers was represented at the 102nd Annual Meeting of the German Association of Gas and Water Engineers, which was held in the Conference Hall, Berlin, on 29th to 31st May, 1961, by the President (Mr. T. C. Battersby, M.B.E.), the former Secretary (Dr. W. T. K. Braunholtz, O.B.E., M.A.) and the Secretary (Mr. A. G. Higgins, M.Sc.).

The meeting was of special significance to The Institution of Gas Engineers, since, at the opening session, a Certificate of Honorary Membership of the Association was presented by the President (Professor Dr.-Ing. Hünerberg) to Dr. Braunholtz in recognition of the service Dr. Braunholtz has rendered to technical developments in the gas industry and, in particular, in fostering international collaboration. The Institution takes justifiable pride in the honour accorded by a sister association to its former Secretary.

Honorary Membership was also conferred on Ing. C. Biemond, former President of the International Water Supply Association, and on Dipl.-Ing. W. Bauser, until recently General Manager of the Zentrale für Gasverwendung. Awards were made to Professor J. Holluta, of the Gas and Water Institute at Karlsrühe, Professor F. Schuster, Technical Director of the Gaswärme-Institut, Essen, and Dipl.-Ing W. Stehn, Chief Engineer of the Hamburg gas undertaking.

The meeting coincided with an International Water Conference and Exhibition, which was held in the Conference Hall, and, in consequence, the technical sessions of the Gas Association were held at the Ernst-Reuter-Haus, a modern building with excellent conference rooms.

The papers presented and discussed included the following:—*

(1) "Co-ordination of Energy Industries in the European Community", by Professor Dr. F. Burgbacher.
(2) "Legal Aspects of Competition in the Energy Industries", by Mr. A. Deringer.
(3) "The Use of Hydrocarbon Gases for Town Gas Supply", by Mr. G. Düwel.
(4) "Changes of Structure in Gas Supply", by Mr. G. Robert (Gaz de France).
(5) "Safety in Gas Supply", by Mr. W. Attig.
(6) "Safety of Domestic Appliances", by Mr. W. Stehn.

* It is hoped to include short abstracts of some of these papers in subsequent issues of the *Journal*.

A number of alternative works visits were available for delegates.

Association Royale des Gaziers Belge

At the Annual General Meeting of the Royal Belgian Association of Gas Engineers, held in the Salle des Milices of the Town Hall, Brussels, on 7th June, 1961, an interesting paper, on "The Storage of Hydrocarbons in Clay Formations", was given by Professor Kaisin, Professor of Geology, University of Louvain. The paper dealt with the theoretical considerations and geological surveys leading to the project to provide an underground storage installation at Antwerp for liquid petroleum products such as propane or butane. An abstract of a paper describing this installation was given in the *Journal* for March, 1961, p. 218.

A visit was arranged to the installation on the morning of 8th June and in the afternoon the delegates visited the works of the Ford Motor Company at Antwerp.

The Institution was represented by the President and the Secretary.

Abstracts of Overseas Papers

The full text of articles abstracted below may be consulted in the Library of the Institution.

Outline of Gas Supply in the Netherlands

J. H. Steinkamp. *Gas-u. Wasserfach*, 26th May, 1961, 591.

The principal producers of gas in the Netherlands are the State Mines (Heerlen), iron and steel industry (Ijmuiden), Sluiskil coke ovens and the gas undertakings of Amsterdam, Rotterdam and The Hague. The three latter also process purchased coke oven gas, refinery gas and natural gas, and distribute gas to the public. The percentage of the total production contributed from the State Mines (13 to 14), iron and steel industry (18 to 18·5) and Sluiskil (1) remained steady in 1957 to 1959, but the proportion contributed by natural gas rose from 12·2 to 21 per cent. In general, the province of Nord-Holland is supplied by the iron and steel industry, Limburg and Nord-Brabant by the State Mines, Zeeland by the Sluiskil coke ovens, and other provinces by natural gas (without or after processing). Only the three large cities and a few others still produce coal gas and water gas. Many of the smaller towns take gas from the large centralized undertakings. The steadily increasing availability of natural gas has made necessary a central organization to administer the production and distribution of gas for the whole country. The National Gas Company (Nationale Gas Maatschappij, or N.G.M.) was formed a few years ago for this purpose. The bodies mentioned above are associated in this Company, the operation of which is outlined by the author.

Second Report of the Committee for the Study of New Gas Distribution Techniques

8th International Gas Conference, 1961, June. IGU/3-61.

The report records the work of the Committee since the publication of its first report (IGU/3-58) in 1958. Developments in different countries in the fields of distribution practice covered by the first report are reviewed, with particular reference to the increasing use of copper and plastic materials

for gas service pipes, improved standards of distribution practice following wider adoption of codes of practice and practical recommendations, reduction in cost of distribution by modification of the pressure, and practice in regard to gas services. An important innovation in certain countries has been the preparation and adoption of codes of practice or recommendations concerning the installation, maintenance and operation of district and service governors. Reference is made to the dehydration of gas in view of developments in long-distance transmission and in gas storage, and to new methods of laying gas mains and services and of repairing mains. Comparative statistics are recorded and analysed for the incidence and causes of fracture of buried cast iron mains, which indicate certain general trends. The Committee has appointed a panel of experts to prepare a model set of safety standards for long-distance pipelines based upon codes existing in the U.S.A. and the U.S.S.R.

Working Repairs on High-pressure Gas Transmission Mains

E. Ducros. *J. des Industries du Gaz*, 1961, April (163-167) and May (199-210).

The author describes, with the aid of numerous drawings and photographs, methods for effecting working repairs on a high-pressure gas transmission main, designed to operate at 67 atm., with no (or only a minimum) interruption of gas supply, in an area having a high density of population and a large number of industrial plants. Actual cases are reported, under three general headings: (*a*) replacement of a defective element or introduction of a new element of main without interruption of supply, (*b*) repair or reinforcement, by means of split couplings, of a main without interruption of supply, and (*c*) cutting out a section and restoration of supply, with minimum interruption, by means of rapid-assembly couplings. The methods and apparatus used, which are largely of American origin, are described in detail and the time-table of operations recorded. The author discusses also the difficulties encountered and the mistakes made.

Liquefied Gas Storage in Caverns

G. R. Benz. 8th International Gas Conference, 1961, June. IGU/20-61.

The first cavern in a salt formation in the U.S.A. was constructed in 1949, and in 1950 the first mined cavern in a shale formation was constructed. Underground storage of liquefied petroleum gas has developed rapidly since 1952, and in 1960 about 2,500 mill. gal of storage capacity was available. Roughly 92 per cent of this is in salt formations, the remainder being in caverns mined in shale, chalk, granite and other insoluble rock. Comparative costs are given for providing storage by various methods used by the gas industry, and it is claimed that underground storage is more economical than storage in steel storage tanks for volumes exceeding 400,000 to 1·2 mill. gal. In addition to liquefied petroleum gas, underground caverns are being used to store high-purity ethylene gas, liquid anhydrous ammonia and high vapour pressure natural gas liquids. Typical underground and surface installations are illustrated by drawings and photographs.

Report of the Committee for the Study of the Interchangeability of Gases

8th International Gas Conference, 1961, June. IGU/4-61.

The report is in four parts, each part contributed by one or more members of the Committee. Part 1, by Dr. F. Schuster (Chairman), discusses the meaning of "interchangeability" and its relation to thermal output, flame stability and combustion quality. The types of town gas distributed in different countries are indicated.

In Part 2, by Theron Mulder, details are given of the methods of determining interchangeability due to Delbourg, Prigg, Holmqvist, Weaver, Devecchi and Grumer-Van Krevelen, and the results obtained by these methods are compared.

Part 3, by A. van der Linden and J. Beyderwellen, deals with the standardization of gas quality in relation to the diversity of gases in different countries, and indicates the increasing popularity of the Wobbe Number as a criterion for determining interchangeability.

Part 4, by G. H. Fuidge and J. A. Prigg, records the present practice in various countries in the use of test gases, and suggests a basis upon which internationally acceptable test gases may be selected and defined. It includes tables showing the characteristics of gases distributed in various countries, present test gases based on distributed gas and on synthetic mixtures, and proposed international test gases.

Development of Modern Commercial Gas Appliances

W. Stehn. *Gaswärme*, 1961, May, 176-183.

Descriptions and photographs are given of a variety of modern German gas appliances for commercial uses, including large-scale catering, confectionery, baking, coffee roasting, butchery, laundries, as well as for commercial cooling purposes, the emphasis being on safe operation, automation and attractive appearance. For each commercial use, there exist appliances with safety ignition, for which the D.V.G.W. is preparing, and will shortly publish, specifications. Large-scale catering equipment is shown, from which the combustion products are evacuated downwards through a special vent. A number of other new devices are described.

Pipe Squeezing

American Gas J., 1961, April, 32-34.

A new technique for closing and reopening small mains and service lines for repairs is described and illustrated with photographs. The pipe responds well to both operations when heated to about 1,600° to 1,700°F. Development of the squeezing and reopening technique, for which a special hydraulic pump is used, enables service connexions to be made without tees. Metallographic tests have shown that hot-pinching and hot-reopening, performed in the proper temperature range, do not produce any detrimental effect on the pipe material.

Forthcoming Meeting

The following meeting has been arranged for the six weeks commencing 1st July, 1961:

LONDON AND SOUTHERN JUNIOR GAS ASSOCIATION

1st July — Ladies' Day. Morning Visit to Southall Works, by kind invitation of the North Thames Gas Board. Members to inspect works. Ladies to inspect a new mobile showroom, containing gas appliances. Luncheon. (Bell House Hotel, Beaconsfield.) Embark at Marlow for river trip. Tea on Board.

In this Issue...

K. G. Eccleshare

C. H. Hirst

K. G. Eccleshare, who jointly won the Institution's Silver Medal for 1960, was born at Derby and educated at Benrose School, Derby, and Derby Technical College. He entered the gas industry in 1926 with the former Derby Gas Light and Coke Company, and trained as a gas engineer under Sir John Ferguson Bell. Mr. Eccleshare transferred to industrial gas on formation of the Industrial Gas Department in Derby. In 1936, he was appointed Industrial Gas Engineer with the former Bristol Gas Company. He was promoted to be Senior Industrial Engineer, Bristol District, in 1955. Mr. Eccleshare was awarded the Society of British Gas Industries Medal in 1939 for a paper to the Western Junior Gas Association.

C. H. Hirst, who jointly won the Institution's Silver Medal for 1960, was educated at Lower Hopton School, Yorkshire, and served in the Royal Navy from 1932 to 1938 and from 1939 to 1945. In 1945-46, he was an engine fitter with the former Croydon Gas Company. After a full-time Intensive Training Course at the Brighton Technical College, he became Works Technical Assistant and Chemist at the Bognor Regis and Chichester Gas Works, and, later, Production Engineer at Southport Gas Works. In 1950, he was appointed Area Technical Assistant to Dr. A. Marsden, M.B.E., Area Scientist, South Western Gas Board. In 1956, Mr. Hirst became Area Industrial Test Engineer attached to Mr. T. H. Pardoe at the South Western Gas Board's Area Industrial Office, and in 1957 was appointed Industrial Gas Engineer for the Bristol District of the South Western Gas Board.

C. Hulse

M. W. Thring

M. W. Thring, Professor of Fuel Technology and Chemical Engineering in the University of Sheffield since 1953, was educated at Malvern College and Trinity College, Cambridge, where he was Senior Scholar in 1937 and graduated with honours in mathematics and physics. In 1938, he was awarded the Student's Medal of The Institute of Fuel, for work on producer gas mains. He joined the British Coal Utilisation Research Association in 1937 as Assistant Scientific Officer, and became Senior Scientific Officer and Head of the Combustion Research Laboratory in 1944. Mr. Thring became Head of the Physics Department of the British Iron and Steel Research Association in 1946, Superintendent of the Association in 1950, and Assistant Director in 1953. In 1949, he was awarded the Sir Robert Hadfield Medal of The Iron and Steel Institute for his studies on open hearth furnaces. He was General Superintendent, International Flame Radiation Research, in 1951. Mr. Thring is a Fellow of the Institute of Physics, and a Fellow and Vice-President of The Institute of Fuel, and was a member of the Fuel Research Board in 1957-58. He has been a member of the Clean Air Council since 1957, of the Fire Research Board since 1960, and of the Council of the British Iron and Steel Research Association since 1958.

C. Hulse graduated at the University of Birmingham in 1941 and proceeded to the steel industry *via* the Ministry of Aircraft Production, where he was concerned with the production and use of clean coke producer gas. Later, he worked under Professor R. J. Sarjant on the general fuel technology of a steelworks, subsequently moving with Professor Sarjant to the University of Sheffield. He is Senior Lecturer in Fuel Technology and Chemical Engineering, under Professor M. W. Thring. Apart from teaching general chemical engineering, his main research interests are in the fields of combustion and aerodynamics. For the past two years, he has been Chairman of the Yorkshire Section of The Institute of Fuel.

Library Accessions

The following are a few additions to the Library since the issue of the *Journal*, Vol. 1, No. 6, June, 1961:

Australian Gas Institute Transactions, 1959.

Benzole Producers Limited :

Determination of Small Quantities of Thiophen in Benzene, by Joyce Pentelow. *Research Paper* 1-1961.

Variation in Benzole Composition during the Carbonizing Cycle of a Coke Oven, by N. B. Coupe, G. W. Girling and R. P. W. Scott. *Research Paper* 2-1961.

Bibliography of Interlingual Scientific and Technical Dictionaries, 4th Edition. (U.N.E.S.C.O., 1961).

British Standard 1134 : 1961 (Centre-line-average Height Method for the Assessment of Surface Texture.)

British Standard 3295 : 1960 (Specification for Unit Heads (Slide-type).

Clean Air Year Book, 1961. (National Society for Clean Air.)

Compagnia Napoletana di Illuminazione e Scaldamento Col Gas, 98° Esercizio, 1960.

National Coal Board Report and Accounts for 1960—Vol. 1 : Report ; Vol. 2 : Accounts and Statistical Tables.

Natural Gas and Methane Sources, by James Lauric. (Chapman and Hall-Limited, 1961.)

Publications of the British Coke Research Association, 1944-1960. *Special Publication* No. 1, 1961.

Scottish Association of Gas Managers, Transactions 1960.

Verband der deutschen Gas-und Wasserwerke e.V. Jahresbericht, 1960.

Water Pollution Research. The Report of the Water Pollution Research Board with the Report of the Director of the Water Pollution Research Laboratory.

District Sections and Affiliated Associations

(a) Notes of Meetings

DISTRICT SECTIONS

London and Southern Section

The Annual Spring Meeting and Luncheon was held, under the chairmanship of Mr. J. A. Hepworth, B.Sc., at the Connaught Rooms on Tuesday, 9th May, 1961; 82 members of the Section, and 37 guests, attended, the latter including representatives of the Ministry of Power, The Institution of Gas Engineers, members of the Area Gas Boards associated with the Section, the Assistant Secretary of The Institute of Fuel, the Chairman-Elect of The Institute of Petroleum, and the Chief Alkali Inspector. It was unfortunate that the meeting clashed with the annual meeting of the National Joint Council for Gas Staffs, which meant that members of The Gas Council were unable to attend. The Section was, however, honoured by the presence of Mr. H. S. Cheetham, President of The Institution of Gas Engineers. The guests included also the authors of the papers given during the session, officers of other District Sections, and representatives of the technical press.

The toast to the "London and Southern Section" was proposed by Mr. H. S. Cheetham. On behalf of the Council of the Institution, he expressed thanks for the support given during his period of office. He congratulated Mr. Hepworth on his programme for the session, which had provided many important papers, and in a survey of the history of the Section he drew attention to the fact that, since its inception in 1875 as the Southern Association of Gas Engineers and Managers, 38 of its members had become Presidents of the Institution. He said that the Institution itself was in good heart; total membership was increasing, but Associate Members were increasing more rapidly than Corporate Members, and he called for applications for transfer from the former class to the latter. He mentioned that, in two years' time, the Institution would be celebrating its Centenary and that Mr. G. E. Currier, O.B.E., was organizing exhibitions to attract the public; the emphasis would be on the new rather than on the old. During his term of office, he had been privileged to visit most of the Sections, and he was very impressed with the tremendous enthusiasm and confidence in the future of the gas industry. He referred to the imminent retirement of Dr. W. T. K. Braunholtz, O.B.E., Secretary of the Institution, who he considered had rendered a tremendous service to the gas industry. Finally, he coupled the toast of the Section with the name of Mr. J. A. Hepworth, B.Sc., Chairman, whom he had known over a period of many years and whose work for the Institution was greatly appreciated.

In his reply, Mr. Hepworth thanked Mr. Cheetham for his kind remarks. He regretted that the clash with the Annual Meeting of the National Joint Council for Gas Staffs had prevented the attendance of the Chairman and Deputy Chairman of The Gas Council and of four area Board Chairmen, and, in particular, he was sorry that his own Chairman was unable to be present. He was in full agreement with Mr. Cheetham that a vigorous Institution was necessary; the work of the Council of the Institution and the various committees was highly appreciated. He expressed his thanks to members for their support during the session; attendances at all seven meetings had been very good, and on several occasions the normal supply of copies of the papers had proved to be insufficient. Discussions had also been of a high quality, and on several occasions had been curtailed for lack of time. He considered the aim of the gas industry was to achieve greater prosperity, and, although Mr. Wilfrid Bailey, Secretary of The Gas Council, had called for a reduction in the cost of gas to 6*d.*/therm, which might not be possible, a move in this direction should be the goal. He concluded by congratulating Mr. A. F. Hetherington, D.S.C., B.A., on being appointed Chairman of the Southern Gas Board.

The toast to "The Guests" was proposed by the Senior Vice-Chairman (Mr. R. M. Farror), who considered that it was a great compliment to the Section that so many distinguished people associated with the gas industry had been able to accept the invitation to the luncheon, and, on behalf of the Section, he extended to them all a most warm welcome.

The reply to the toast, given by Dr. J. S. Carter, the Chief Alkali Inspector, was punctuated by several humorous anecdotes. He referred to his early association with Mr. Hepworth, and, in thanking the Section, on behalf of the guests, for hospitality, he offered his best wishes to all those concerned in the future of the gas industry.

Most of those present at the luncheon attended the subsequent meeting in the afternoon to hear Mr. J. A. Hepworth, B.Sc., give his Chairman's Address entitled "Gas Production—Progress and Problems". By tradition, there was no discussion, but, in proposing the vote of thanks, Dr. A. E. Haffner said the paper was very provocative and he was sure that a discussion of its contents would take place outside the meeting.

South Western Section

A general meeting of the Section was held at Exeter on Wednesday, 1th May, 1961, and attended by about 80 members and guests. The meeting was preceded by luncheon and a visit to the South Western Gas Board's Exeter manufacturing station, where the new Appleby-Frodingham desulphurizing plant was under construction. The meeting, held at the Rougemont Hotel, was presided over by the Chairman of the Section, Mr. T. W. Jackson.

Congratulations were extended to Mr. K. G. Eccleshare and Mr. C. H. Hirst on being awarded the Institution of Gas Engineers Silver Medal for their Paper "Recent Industrial Gas Developments in the South West", given at Bristol

on 8th December, 1960. This was the second year in sucession for the South Western Section to be so honoured.

Mr. S. F. Tucker and Mr. H. E. J. Hardman, both Associates of The Institution of Gas Engineers, were elected members of the Section.

Mr. L. Baldwin, Works Engineer and Manager, South Western Gas Board, Exeter, briefly introduced a paper, "The Exeter Installation of an Appleby-Frodingham Desulphurization Plant—A Description", which was illustrated by diagrams and coloured slides. Contributors to the discussion, opened by Mr. T. W. Clapham, included Mr. C. H. Hirst and Mr. A. P. Jennings.

Two films were shown dealing with the Sharpness Bridge incident. One described the measures taken to provide a temporary gas supply to the Forest of Dean after 25th October, 1960, when two oil barges had collided with the Severn Bridge and exploded, causing two spans of the bridge to collapse into the river. The second film showed the construction and launching operation of the permanent twin 10 in. diameter submarine gas main under the River Severn, which was completed on 21st December, 1960.

The Chairman introduced Mr. R. Pratt, Distribution Engineer, Cheltenham/Gloucester Districts, South Western Gas Board, who presented for discussion a paper, "Twin 10 in. Diameter Submarine Gas Mains under the River Severn".

A vote of thanks to Mr. Pratt and Mr. Baldwin was proposed by Mr. G. F. Oliver.

The traditional luncheon collection in support of the Institution Benevolent Fund yielded £7 4*s.* 9*d.*

JUNIOR GAS ASSOCIATION

Manchester District Junior Gas Association

(*a*) The Manchester and District Junior Gas Association visited the Derbyshire Silica Firebrick Company's works at Friden, near Buxton, on 26th April, 1961. The party was entertained to luncheon at Buxton and welcomed by Mr. Ernest West, Chairman of the Company, who said that the Association had previously visited the plant in 1921 and 1950.

Since his father founded the Company in 1892, said Mr. West, the works had been progressively mechanized for the handling of materials and for various processes; today, this was necessary to meet the exacting requirements of the industries the company served.

Mr. W. F. S. Howell (Senior Vice-President of the Association) apologized for the unavoidable absence of the Association's President, Mr. J. A. Taylor. He recalled his personal and early experience of Friden refractories.

Mr. C. Worswick, the Association's auditor, said that Mr. H. Crompton, Mr. H. Dobson, Mr. P. Faulkner, Mr. L. R. Mather, Mr. J. R. Teale, Mr. N. Wickstead and Mr. A. H. Woods had been elected to the seven vacancies on the Association's Council for 1961-62.

A tour of the works took place after the luncheon, and the visitors saw, among other things, the preparation and quality control of materials, brickmaking, setting, firing, drawing, inspection and loading. There was much interest in an automatic plant for improving the production of siliceous materials.

Mr. N. Olsen (Immediate-Past President), on behalf of the Association, thanked Mr. West and his Company for such an interesting visit, and Mr. S. J. Beale, Managing Director, responded on behalf of the Company.

(*b*) On Tuesday, 9th May, 1961, the President and 70 members of the Manchester Junior Gas Association joined with the President and 50 members of the Yorkshire Junior Gas Association in a visit to the Thorncliffe Works of Newton Chambers and Company, Limited.

The visit began at 10.30 a.m. with a tour of the exhibition where old plans and documents were inspected together with illustrations of all the products made by the Company.

Members were then taken by motor coach on a works tour, during which they visited the light and heavy foundries, the machine-shop and the construction-shop, where parts of a 1,800-ton excavator were seen.

After being received by Mr. Bovill, the Managing Director, luncheon was served at the Newton Hall. Mr. Bovill welcomed the visitors, and Mr. J. Edgar, President of the Yorkshire Junior Gas Association, responded on behalf of both Associations.

After luncheon, the visitors were taken through the excavator works, the chemical works and the hydro-refining pilot plant, after which they returned to the Newton Hall for tea.

Mr. J. A. Taylor (President of the Manchester Junior Gas Association) expressed the thanks of the visitors to Mr. Bovill and the directors of Newton Chambers and Company, Limited, for their hospitality.

(b) Abstracts and Discussions of Papers

Copies of the complete papers abstracted below are available for consultation or loan in the Library of the Institution.

DISTRICT SECTIONS

South Western Section

"The Exeter Installation of an Appleby-Frodingham Desulphurization Plant—A Description", *by*

L. Baldwin, A.M.I.Gas E., Engineer and Manager, Basin Gas Works, South Western Gas Board, Exeter.

Paper delivered in Exeter on 10th May, 1961.

In pursuing a sound policy of integration of areas of supply and the concentration of gas production at major manufacturing stations, the South Western Gas Board has been enabled to install the most modern type of gas-making and associated plant, which has in no small measure contributed to the relative stability of the gas industry in the South West and in an improvement, in many instances beyond recognition, in the industry's service to the consumer.

A further major improvement in the Board's service to consumers must now be faced if the industry is to maintain its position alongside its competitors. For many years, it has been the dream of all gas engineers and salesmen in the industry to be able to supply and sell a sulphur-free gas; whilst many excellent schemes have been devised to this end, the economics involved have precluded general acceptance.

A bold decision has been taken by the South Western Gas Board to install at Exeter a major item of plant to remove almost completely and in one process the sulphur compounds associated with coal gas production. Exeter has been chosen for this first installation mainly, perhaps, because of the increasing need for further purification capacity, and in order to utilize to its fullest extent the installed and potential gas-production capacity.

As the plant is not yet fully operational, the scope of the paper is confined to an appreciation of the process and some construction details.

The description of the plant falls naturally under two headings: The first deals with the desulphurizing plant, in which both hydrogen sulphide and organic sulphur compounds are removed from the gas, and the second with the complementary recovery of sulphur in the form of sulphuric acid. The acid plant may be regarded as conventional, but the desulphurizing plant incorporates techniques that involve relatively new applications to coal gas purification.

Discussion

Following is a brief summary of the discussion opened by **Mr. T. W. Clapham,** and in which **Mr. C. H. Hirst** and **Mr. A. P. Jennings** took part.

(1) Opinion was that the Board was taking a very progressive line in introducing the Appleby-Frodingham plant, as the one plant reduced labour and produced a finished product, thus overcoming the difficulty of disposing of spent oxide.

(2) A question was asked: "When is it likely that the sulphur-free gas will be available in the Bristol district, in order to encourage further expansion of industrial gas sales?" It was confirmed that Bristol would be considered in the future.

(3) Discussion took place on the maintenance of the plant, and it was said that it should run for 10 years and then be overhauled in a very short time with the co-operation of the contractors.

"Twin 10 in. Diameter Submarine Gas Main under the River Severn", *by R. Pratt, A.M.I.Gas E., Distribution Engineer, Cheltenham/Gloucester Districts, South Western Gas Board.*

Paper delivered in Exeter on 10th May, 1961.

The paper describes briefly the incident at Severn Bridge when a section of the bridge, carrying a high-pressure gas main, was completely wrecked, cutting off gas supplies to the Forest of Dean.

A temporary supply was restored by suspending a polythene tube on a cable over the gap. Work was begun on the laying of a new permanent high-pressure main from Gloucester to the Forest of Dean. It was necessary for a section of this main to pass under the River Severn, and the Author describes how twin 10 in. diameter mains were laid in the river bed, using the "ploughing and pulling" method.

The two 10 in. steel mains, each 545 ft long, were joined together, completely encased in a reinforced concrete coating and placed on special pneumatic conveyors at right-angles to the river bank. The front end of the concreted pipeline was connected to a 10-ton plough and attached to a massive winch by a 1¼ in-diameter steel cable. The whole unit was then pulled into the river bed by the winch. The plough cut a trench in the river bed, and the pipeline was laid in immediately, thereby avoiding pipe movement and silting up of the trench.

The whole operation was completed in 31 days, and the time taken for the actual "ploughing and pulling" through the river bed was 45 min.

Discussion

Following is a brief summary of the discussion opened by **Mr. G. C. Gunston,** and supported by **Mr. D. H. P. Hammond, Mr. W. G. G. Snook** and **Mr. A. P. Jennings.**

(1) Congratulations were extended to all concerned in the operation and in overcoming all the very real difficulties, including flooding, that were presented. The question was asked: "What precautions were taken in case of any fractures in the concrete in the future?" It was said that concrete was used only to weight the pipe, protection of the main was bituminous solution with a woven-glass reinforced sheathing.

(2) It was said that concrete would crack, due to stressing, but it was replied that expansion joints had been incorporated in predetermined cracking areas and at regular intervals.

(3) In reply to a question as to what survey had been made for the trench route, Mr. Pratt stated that a profile was taken through the river bed and it was found that there was no rock formation. Divers could not be employed, because of high current speed.

(4) In reply to a question, "How was it known when the main was actualy in the trench?", it was stated that whereas if the trench had been cut first and the pipe laid later the water current would have filled the trench with silt, this was avoided by attaching the pipes to the plough, which precaution ensure that the pipe was placed in the trench, approximately 2 ft below the river bed.

JUNIOR GAS ASSOCIATIONS

Manchester Junior Gas Association

"Development for Tomorrow Aids Industrial Sales Today", *by G. W. Robertshaw, A.M.I.Gas E., Industrial Development Engineer, Industrial Development Centre, Manchester, North Western Gas Board.*

Paper delivered at Blackburn on 23rd March, 1961.

The introduction to the paper refers to the possibility of a reduction in the price of gas for industrial purposes consequent upon the development of new techniques in gas production. The impact of the resultant great increase in demand for industrial gas on the existing sales organization is discussed together with the need for suitable aids to simplify the installation of gas-fired industrial plant.

A method of assisting the industrial gas sales engineer at the moment, which would be of the greatest benefit if the gas industry's competitive position improved, is to take every advantage of the "packaging" technique in the design of equipment. This not only increases the sales appeal, but reduces considerably the field work, with associated savings in time and cost.

The paper is, therefore, devoted to the development over two years of "packaged" burner equipment of a type suited for the conversion of solid-fuel boilers to gas firing, and many other industrial applications.

Reasons are put forward for the apparent lack of prior development on these lines in this country as compared with other countries enjoying the large-scale use of natural gas.

This is followed by an outline of the work carried out over the past two years at the Manchester Industrial Gas Development Centre, describing the first models of burners and comparing them with similar equipment produced in the U.S.A. A section is devoted to basic design requirements for nozzle-mixing burners and their effect upon the overall design of a package burner.

District experiences are summarized leading up to a redesign incorporating the results of a further study of components aimed at size and cost reduction.

Further district installations of the Mk.11 burner are described giving the results of tests carried out by the National Industrial Fuel Efficiency Service on the application of the unit to a central heating boiler.

Following further detail improvements and tests, an interim report was produced with the purpose of obtaining further installations. Some eight installations involving 15 burners with an aggregate gas consumption of 50,000 ft³/h are described, giving some results of efficiency tests.

The use of the unit for industrial processes other than heating boilers is illustrated by the description of a nylon heat setting machine to which one of the burners has been applied. A further experimental installation to a high-temperature foundry process is detailed to give a lead to an entirely different range of application.

Brief ideas are given on the lines of future development.

In the conclusion, it is considered that an up-to-date piece of equipment has been produced for which there is a market in today's conditions. This market could be increased greatly should the gas industry's competitive position be improved.

Discussion

Mr. J. Ward (Manchester) said it gave him great pleasure to open the discussion on Mr. Robertshaw's paper. Although Mr. Robertshaw and he worked in the same office, he had taken no part in the development of the package burner. His "headaches" and those of all district engineers were confined to installation, operation, and maintenance, and his remarks were largely based on practical experience with boiler conversions.

First of all, there were two points upon which he would like to comment: There was a certain amount of apprehension in the minds of some industrial engineers that this new approach of packaged units was something of a condemnation of previous methods. Nothing could be further from the truth. Development meant progress, and, in the fullness of time, the package unit, as it is now, would also be outdated. His second point might well be the subject of differing opinions. If the package unit, using fan air, was more efficient than natural-draught burners, then automatically there was a tendency to imply that the existing designs of purpose-made boilers was also less efficient. He found himself accepting this, with certain reservations. Fan air units would, he thought, not find favour on the smaller range of boilers in domestic and some commercial properties where noise level was an important factor. Capital cost also might exclude them. On the larger sectional boiler, there might well be a good case for packaged units, but, if high efficiency was to be achieved, sectional boilers would have to be redesigned to provide maximum internal heating surface. As mentioned by Mr. Robertshaw, one boiler manufacturer was already doing this with a view to using oil burners. He had now decided to adopt the package burner as well.

Turning to the application of package burners to boiler conversions, Mr. Ward underlined the point made by Mr. Robertshaw that the type and size of boiler had a great deal

to do with the optimum efficiency that could be achieved. It would be seen that much better results were obtained on the 410K. Britannia, which had a longer internal flue travel, than with the six-section Colonel, and this would be so with any burner, although it was found that the stack temperature could more easily be reduced with a package unit.

The results on the 410K. Britannia were obtained without any modification to the boiler, whereas on the Colonel several were necessary. The major modifications were as follows:—(*a*) When a boiler was fitted with a steel case, as opposed to conventional boiler lagging, it was important to ensure that there was no leakage of air into the combustion chamber. This usually occurred between the boiler sections. (*b*) In order to ensure maximum travel of hot gases within the boiler, it might be necessary to blank off secondary flue ports between the boiler sections. Boiler manufacturers could usually supply cast iron plugs for this purpose. (*c*) On certain types of boiler, the flue offtake might be too large for the rated output, and damper adjustment was necessary. This was the case with the six-section Colonels where the flue diameter was in keeping with a 10-section boiler.

On the electrical side, there were two points that must be observed, and both concerned electrical feedback to the unit. Electrical clock controllers should have the on/off control connexion separate from the motor drive. Where two boilers were under the control of one panel, it was necessary to fit a contact breaker to isolate one boiler from the other in case of pilot-flame failure.

Mr. Ward said he had reason to believe that some industrial sales engineers felt that the package units should be more fully perfected at the Centre before release, and that the design should much more quickly be handed over to a manufacturer. His own view was that engineers should be prepared to share in development by co-operation in field tests on their districts, and to pass suggestions for modification back to the Centre. On the second point, no manufacturer would readily undertake commercial production unless it could be shown that a market existed.

He was rather disappointed that Mr. Robertshaw had confined his paper to one type of package burner when so many other types had been fabricated and manufactured by his department; perhaps Mr. Robertshaw would comment on this.

Finally, he congratulated the Author on a paper that clearly illustrated the problems and difficulties to be overcome in design and development work. He was convinced that the service provided by Mr. Robertshaw to those whose job was the selling of gas in a very competitive fuel market was invaluable, and he wished more power to his elbow.

Mr. Robertshaw thanked Mr. Ward for supporting the principle of the package burner, for obtaining orders for units, and for his invaluable assistance with installation in the Manchester area.

Dealing with the first point in the listed comments, he agreed that not all previous methods of boiler conversion were necessarily condemned; there were still occasions when the older methods might be more suitable; in the majority of instances, however, the new burner could show advantage and, judging from its reception by purchasers and independent authorities, it would normally be preferred.

It was important to keep a package burner conversion in perspective when comparing with boilers that were purpose designed. It was more efficient than the average natural-draught burner when used on a conversion, and was equal to, or almost equal to, many purpose-designed boilers. Where a purpose-designed boiler was correctly sized for the installation to which it was fitted, a boiler converted with a package burner would show little advantage. It could feasibly show an advantage if the purpose boiler were grossly over-sized, but this was not likely. Since the capital cost of the fan-assisted burner was relatively high, it was agreed that it was not likely to find favour for domestic and other small boilers. Efforts were being made to further simplify and, therefore, reduce the burner cost to that which made its advantages a commercial proposition for smaller outputs than those listed in the North Western Gas Board Industrial Centre Report No. 138.

The comments on the practical application of the burner to boilers are very timely. It is emphasized that it is not sufficient to install a unit on any boiler, and to expect first-class results; attention must be given to the details mentioned. One attraction is, however, that they are very straightforward and, once they are carried out, the results can be obtained with certainty and can be maintained.

The final report on the unit would include details of suitable electrical time-switches for the avoidance of feedback.

It was readily admitted, said Mr. Robertshaw, that there had been many teething troubles, all concerned with the flame rectification flame-protection equipment. It was hoped that engineers would not be discouraged by these; it should be realized that only by installing quite a number of units in different circumstances could all the snags be found in a relatively short time. To perfect fully the equipment before releasing it for use would involve a delay of up to a year, and even then it could not be guaranteed to be perfect. The Author regretted that other types of package units had not been covered in the paper, but hoped that these would be dealt with in due course.

Mr. J. R. Teale (Bury) said that Mr. Robertshaw's comment that the operation of the burners was independent of flue conditions had interested him very much. Did he mean that there was no necessity to have a down-draught diverter? If this was so, the cost of converting gas appliances with this form of burner would be extremely economical.

It appeared that virtually a complete circle had been turned, because, as most gas engineers would recall, the radiant tile type of burner was utilized for central heating boiler conversions some years ago. This burner had an adjustable secondary air inlet that was designed to close automatically during shut-down, thus preventing heat loss through the flue during the period of shut-down.

This type of burner was followed by the post-aerated burner floats, "Hypact" burner and now, it seemed, the package burner, one of the virtues of which was the prevention of heat loss through the flue during shut-down.

Although thermal efficiencies of 75 and 80 per cent were claimed for gas-fired boilers, these efficiencies were determined under full-output operation, whereas it was desirable to submit an operating thermal efficiency that took into account the period of shut-down. Consequently, if cold air were allowed to pass through the appliance during the shut-down period, the overall thermal efficiency could be reduced considerably. It was obviously desirable, therefore, that the secondary air should be controlled during shut-down periods. Mr. Teale would be pleased, he said, if Mr. Robertshaw would inform him of any method of controlling automatically the air flow through a horizontal steam boiler during a shut-down period.

The North Western Gas Board's Central Lancashire Group had made great use of the Industrial Development Centre, and had received full co-operation from Mr. Robertshaw and his staff. They had also found, in the Central Lancashire Group, that industrialists, when informed of the availability of gas equipment such as the package burner, had been very interested in, and in many cases willing to experiment with, the burner. In every case where the Industrial Development Section has been called in, the business had been concluded satisfactorily in the form of orders for equipment. This seemed to indicate to Mr. Teale that a large number of industrial consumers were still not aware of the availability of the technical service and also of what plant was available. It could be said that it was the duty of the industrial engineer to inform such industrialists, but, as Mr. Robertshaw had said, in the past industrial engineers had been so busy that they just had not had the time to contact everybody. This situation was gradually improving due to the influx of technical assistants, but, even so, he was of opinion that greater publicity was desirable and that the drum was not being beaten hard enough.

Mr. Robertshaw replied that the package burner was not sensitive to flue conditions. Provided that the flue would take away the products, the unit would give satisfactory operation without fitting a down-draught diverter. It was, however, advisable to remove any flue-cleaning doors to break the pull

and to provide an inlet for dilution air. In the event of down-blow, combustion would not be interfered with to any extent. It would be realized that this feature removed an obstacle that was always present when carrying out natural-draught conversions.

Regarding the automatic air shutter device, the idea was good enough, but the difficulty lay in maintenance under boiler-house conditions. The same problem did not apply to the package burner, where the reduced air flow was obtained by stopping the fan, leaving only a small area for flow.

The same method could obviously not be used for a horizontal steam boiler. This required a flue damper, power-operated, with interlocking switches. At the moment, any such device would have to be constructed, but, if greater demand for it arose, it could well become a development project.

Mr. H. Hocking (Farnworth) said he understood from Mr. Robertshaw's earlier statements on the package unit, that conversion of a boiler of less than 150,000 to 200,000 Btu output would not give an efficient installation. He would like Mr. Robertshaw to clarify this point.

In the past, he had had experience with the new flame-failure device, and also hot air units that had been installed to Mr. Robertshaw's design. Teething troubles had been quite numerous. The earlier pattern flame-failure device, *etc.*, had now been changed for a modified version, which, he was pleased to say, was so far proving quite satisfactory.

He was pleased that Mr. Robertshaw had been given more staff at the Industrial Development Centre to carry out development work, and thought that in the near future benefit would accrue in connexion with package units, *etc.*

Mr. Robertshaw said that at the moment the capital cost of the package burner was such that it was out of the question for small boilers. As previously stated, however, this was to receive attention.

It was agreed that staff difficulties were a problem and caused some additional district work, but the position had considerably improved.

Mr. J. C. Saint (Blackpool) said he also would like to pay tribute to Mr. Robertshaw, not only for his work in the development of the package burner, but also on the many other projects he had developed. In addition, he would mention, to allay any anxiety that distribution and production colleagues might have after listening to certain remarks on the package burner, that the original installation of the eight units on a travelling oven, mentioned by Mr. Robertshaw in his paper, had now been in constant use, day in and day out, for the last 18 months, with very little maintenance. The Board's client was most pleased with their functioning, because on this particular oven straight-line temperature conditions were achieved automatically.

Mr. Robertshaw thanked Mr. Saint for his comments on the subsequent operation of the burners on the travelling biscuit oven.

Scottish Western Junior Gas Association

"Pipeline Under the Forth", *by R. O. Emmony, M.I.Gas E., Distributing Engineer, The Scottish Gas Board.*

Paper delivered at Dunfermline on 7th April, 1961.

The paper opens with the reasons that made the underwater crossing necessary, and goes on to discuss some of the problems faced in selecting a site.

Initial planning and design in consultation with a contractor experienced in this work involved consideration of other methods before the final decision to lay twin pipelines in trenches dredged in the river bed.

Removal of condensate and prevention of corrosion in the pipeline were other considerations discussed; and description of the operation is preceded by detailed explanation of negotiations that took place prior to work commencing in the autumn of 1959.

The actual pipe pulling operation was preceded by a number of steps that all proved immeasurably important to the success of the job; these included holiday detection, concrete coating of pipes, pressure tests, positioning of conveyors, and dredging.

The paper explains very clearly each stage, finishing with the reinstatement of the river bank and the final pressure tests.

A cost analysis gives some idea of the extent of the venture.

Drawings and tables make the paper a worth while reference to all those interested in high-pressure distribution engineering.

Discussion

The discussion was opened by **Mr. J. R. Denoon,** Divisional Distribution and Customer Service Engineer, Glasgow and Western Division, The Scottish Gas Board, and a considerable number of those present took part in a general discussion on the supergrid. **Mr. J. Sutcliffe,** the Board's Grid Engineer, answered questions on the life of the pipeline, the selection of the site crossing, equipment, effect of "dry gas", and gas escapes and testing.

General Notices

Preliminary Notice of a Joint Meeting

A joint meeting between the British Coke Research Association, The Coke Oven Managers' Association and The Institution of Gas Engineers has been arranged to be held at 2.30 p.m. on Wednesday, 1st November, 1961, in the Grand Council Chamber of The Federation of British Industries, 21, Tothill Street, London, S.W.1. The chairman at the joint meeting will be T. C. Battersby, Esq., M.B.E., President of The Institution of Gas Engineers.

Further details of this joint meeting will be given in the next issue of the *Journal*.

Post Higher National Certificate Course

A two-year part-time Post Higher National Certificate Course in Gas Engineering has been arranged at Enfield Technical College, for the 1961-62 session, for students preparing for the Associate Membership Examination of The Institution of Gas Engineers. To be admitted to the first year of the course, students should have obtained a higher National Certificate in Civil or Mechanical Engineering. In each year, the course will last for two terms only (i.e., Autumn and Spring), and the fee for the course is £4 7*s*. 0*d*. per term. Students who complete the course will take the Associate Membership Examination of The Institution of Gas Engineers in April, 1963.

Further particulars and a form of application for admission to the course, which should be made as soon as possible, are obtainable from Mr. S. G. Chapman. B.Sc.(Eng.), Head of the Department of Civil and Mechanical Engineering, Enfield Technical College, Queensway, Enfield.

27th Autumn Research Meeting

The 27th Autumn Research Meeting of The Institution of Gas Engineers will be held in The Church House, Westminster, London, S.W.1, on Tuesday and Wednesday, 21st and 22nd November, 1961.

Further particulars of the Meeting will be sent to all members of the Institution in due course.

Discussions

The following discussions of Institution and Gas Council papers presented to Meetings of the Institution are available from the Institution as separate *Communications* at 3*s*. 6*d*. each, post free.

2nd Dempster Travelling Fellowship Report: Continental Uses of Gas in Industry, by T. Ward. (*Communication No.* 561/300.)

"Flame Traps for Use with Town Gas/Air Mixtures", by P. A. Cubbage. (*Gas Council Research Communication GC*63/54.)

Industrial Radiology

The Non-destructive Testing Society of Great Britain has arranged a Summer Conference to be held at Chester between 21st and 23rd September, 1961, the theme of which is to be "Industrial Radiology Today", and will be based on papers and discussion on the application of newly developed aspects of industrial radiology. The papers will include such subjects as low KV radiography, xeroradiography, linear accelerators, betatrons, large gamma-ray sources for radiography, and current safety regulations.

Further particulars are obtainable from the Conference Secretary, Mr. I. M. Barnes, Materials Laboratory, de Havilland Aircraft Company, Limited, Manor Road, Hatfield, Herts.

International Dictionary of the Gas Industry

The International Dictionary of the Gas Industry initiated by the International Gas Union will shortly be published. Full details were given in a brochure enclosed in the June issue of the *Journal*, which was accompanied by a subscription form.

Any members of the Institution who wish to take advantage of the reduced price of £3 12*s*. 6*d*. (about 60 per cent of the full rate) should return that form to the Secretary of the Institution before 24th July, 1961.

Institution Necktie

The Council of the Institution, in response to a number of requests from members, has arranged for the manufacture of an Institution tie, which will enable members readily to identify other members they meet and with whom they associate both in work and socially.

The design incorporates a motif taken from the Institution's coat of arms and consists of a crown and two crossed torches. The tie is made of silk with the motif on a blue background.

In order that the sale of the ties shall be restricted to members of the Institution they will be obtainable only from the headquarters of the Institution at 17*s*. 6*d*. each, post free. This price will enable a contribution of 5*s*. for every tie sold to be made to the Benevolent Fund of the Institution.

Orders should be accompanied by the appropriate remittance and should be addressed to the Secretary, The Institution of Gas Engineers, 17, Grosvenor Crescent, London, S.W.1.

Library

The Library and Reading Room of the Institution are open on weekdays between 9 a.m. and 5.30 p.m. Members may borrow books by post, excepting books of reference and certain others, on application to the Secretary.

Benevolent Fund

Contributions to the Benevolent Fund of the Institution may be paid at any time to the Honorary Secretary of the Benevolent Fund, 17, Grosvenor Crescent, London, S.W.1. It is a convenience if annual contributions are made by banker's order, and it is particularly advantageous to the Fund if such contributions are made by Deed of Covenant, whereby the Fund is able to reclaim from the Inland Revenue an appropriate sum in respect of income tax paid by the contributor. Further particulars, with deed forms and banker's orders for completion, are obtainable from the Honorary Secretary of the Fund.

Officers of District Sections and Affiliated Associations

Sections

Eastern

Chairman :	E. H. Winch, M.I.Gas E., Eastern Gas Board, 52, Sidney Street, Cambridge.
Honorary Secretary and Treasurer :	J. Hunter-Rioch, M.B.E., M.I.Mech.E., M.I.Gas E., Eastern Gas Board, 52, Sidney Street, Cambridge.

London and Southern

Chairman :	J. A. Hepworth, B.Sc., M.I.Gas E., North Thames Gas Board, Monck Street, London, S.W.1.
Honorary Secretary and Treasurer :	J. T. Veryard, B.Sc., M.I.Gas E., South Eastern Gas Board, Katharine Street, Croydon.

Manchester and District

Chairman :	N. C. Sturrock, M.I.Gas E., North Eastern Gas Board, 48, James Street, Harrogate.
Honorary Secretary :	J. Castle, B.Sc., M.I.Gas E., North Western Gas Board, Radiant House, Bold Street, Liverpool, 1.
Honorary Treasurer :	A. Harrison, M.I.Gas E., 297, Bramhall Lane South, Bramhall, Cheshire.

Midland

Chairman :	F. Harvey, M.I.Gas E., West Midlands Gas Board, Tame Bridge, West Bromwich Road, Walsall.
Honorary Secretary :	D. K. Green, M.I.Gas E., West Midlands Gas Board, Foleshill Road, Coventry.
Honorary Treasurer :	J. H. Wainwright, M.I.Gas E., West Midlands Gas Board, Powke Lane, Blackheath, Birmingham.

North of England

Chairman :	K. E. Brown, A.M.I.Gas E., Northern Gas Board, Market Street, Newcastle-upon-Tyne.
Honorary Secretary :	W. Cummings, A.M.I.Gas E., Northern Gas Board, 30, Grainger Street, Newcastle-upon-Tyne.
Honorary Treasurer :	A. Fidd, M.I.Gas E., Northern Gas Board, 19 King Street, Penrith, Cumberland.

South Western

Chairman :	T. W. Jackson, M.I.Gas E., South Western Gas Board, 9a, Quiet Street, Bath.
Honorary Secretary :	F. C. Gay, M.B.E., F.C.I.S., Assoc.I.Gas E., Radiant House, G.P.O. Box No. 141, Bristol, 1.
Honorary Treasurer :	T. A. Nicholson, A.M.I.Gas E., South Western Gas Board, 34, Bridge Street, Taunton.

Wales and Monmouthshire

Chairman :	S. L. Wright, B.Sc., M.I.Gas E., Wales Gas Board, Grangetown Gas Works, Cardiff.
Honorary Secretary :	J. Powdrill, M.B.E., A.M.I.Gas E., Wales Gas Board, Bute Terrace, Cardiff.
Honorary Treasurer :	O. P. Cronshaw, M.B.E., M.I.Gas E., Wales Gas Board, 93, Wellington Road, Rhyl, N. Wales.

Affiliated Associations

Irish Gas Association

President :	W. A. Campbell, M.I.Gas E., Belfast Corporation Gas Works, Ormeau Road, Belfast.
Director :	N. J. Robertson, Assoc.I.Gas E., Alliance and Dublin Consumers' Gas Company, Dublin, Eire.

Scottish Association of Gas Managers

President :	D. Beavis, M.I.Gas E., Scottish Gas Board, 1, Rothesay Terrace, Edinburgh.
Honorary Secretary and Treasurer :	W. Kirk, M.I.Gas E., Kessington, 29, Union Street, Greenock.

British Junior Gas Associations' Joint Council

Chairman :	T. W. Pickthall, A.M.I.Gas E., North Western Gas Board, Stanley Buildings, Silver Street, Bury.
Honorary Secretary :	L. G. Townsend, M.Sc., M.I.Gas E., North Western Gas Board, Hind Street, Birkenhead, Cheshire.